THE ART OF PRACTICAL MEASURING

Eaſily Perform'd,

By a Two Foot RULE, Which ſlides to a FOOT.

On which is the *beſt Meaſure* of *Round Timber* the Common way. Alſo, the *true Meaſure* of *Round*, *Square*, or other *Timber* or *Stone*, *Board*, *Glaſs*, *Paving*, *Painting*, *Wainſcot*, &c. *Gauging* of *Caſk*, and *Gauging* and *Inching* of *Tuns*.

CONTAINING,

Brief Inſtructions in *Decimal Arithmetick*. The beſt way of uſing the *Logarithms* according to Mr. *Townley*. The Uſe of a new *Diagonal Scale*, of 100 parts in a quarter of an Inch, applied to *Gunter*'s Chain.

AND LASTLY,

Some Uſeful Directions in *Dialling*, not hitherto Publiſhed.

By *H. C.* Gent.

LONDON, Printed for *Thomas Bennet*, at the *Half-Moon* in St. *Paul*'s Church-yard. 1690.

TO THE READER.

THE general Approbation of this Rule, hath caused me to review the Book. I have explained some things, and added others, which I thought useful.

Whether Mr. Townley's contrivance of the Indices be treated of any where, but in Sir Jonas Moor's Mathematical Compendium, I could never learn; nevertheless, the Extraction of the Square and Cube Roots of Decimals, acccording to that contrivance, being there wanting, I have given you it here, so that the Root of a Decimal, whose Logarithms hath such an Index, is found with equal ease, as that of a whole Number.

I have shewn how to find the Logarithm to any Number of six places, in Mr. Wingate's Tabulæ Logarithmicæ (omitted in the explanation of the Tables) by the differences

differences at the bottom, and a slip of this Rule, it supplying the place of a Table of Proportional parts, which adds much to the usefulness of the said Book, in giving the Logarithm of any Number, as far as a Million, with little trouble.

The Gauging of Tuns is here shewn according to the Modern Practice of Inching. I have given you a near way of Measuring a Solid that tapereth strait, as also of finding the Total Content of the Conical Tun and Stand, from Mr. Everard; *whose Numbers for ten Inches difference of Diameters, for the Parabola and Conoeid, I have also inserted.*

The making the most useful Dials, viz. *the Horizontal, and the upright ones, is rendred here easie and certain, especially the* North *faces; some of which are equally needful as the* South. *And because it is not commendable to put more or fewer hours on a Plane, than the Sun (supposing no obstacle) will at some time of the year shine on; or to make the Style over long or over short, I have given you a way to find both by an easie Calculation. And lest any thing should be wanting, that might*

might ſeem neceſſary to this Treatiſe, I have added Tables of the Suns Declination.

Laſtly, here is added by Mr. John Warner, (*whoſe care in the directing the Impreſſion I here thankfully acknowledge*) *a curious Scheme of both ſides of the Rule and of the Scale.*

1. *And that I may leave nothing obſcure or uncertain, know, Courteous Reader, that the Subdiviſions mentioned page* 32, *line* 15, *are thoſe on the Square line, from* 4 *to* 10, *which were not on the firſt made Rules, but put on after, to their great Improvement.*

2. *That the words* (*from* 10 *to* 40 *into* 4 *parts*) *p.* 24. *l.* 6. *are to be underſtood from* 10 *to* 40, each whole *into four parts.*

3. *In the Inſtrument deſcribed, p.* 75. *let the Rule ſaid to be ſix inches long, be nine inches long; however, ſomething longer than the Semi-diameter, for there needs no exact proportion. Alſo, let the Diameter be at leaſt an inch diſtant from the edge of the Board, that there may be ſpace to fix the one Rule to the other behind the Center.*

4. The

4. *The Aſcentional difference mentioned thrice, cap. 9. of Dialling, muſt be that at the greateſt Declination of the Sun.*

5. *If any think that the Style is too ſhort, as directed page 95, he may take the length of the Hour-line to the outward border, and proceed, as directed there; ſo the ſhadow, at the ſhorteſt, ſhall reach ſo far.*

For other faults, I refer you to the Printed Errata, intreating your favourable Cenſure, it being Natural for Man to Err. I may alſo alledge this in excuſe, That living far from the Preſs, I ſaw not the Sheets till they were wrought off, and ſo paſt Correction any other way.

Henry Coggeſhall.

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DIALLING.

The

THE *Art of* Practical Measuring *easily Performed*, &c.

Part I.

The Introduction.

THE Art of Measuring depends wholly upon Geometry and Arithmetick; it is therefore absolutely necessary for a Measurer to have a competent Skill in both.

1. In Geometry; It is requisite that he know the three Kinds of Quantity, as a Line, a Superficies, and a Solid. That a Line hath only length; That a Superficies hath length and bredth; That a Solid hath length, bredth and depth.

Moreover, That each kind of Quantity is measured by some common Measure thereunto assigned, as a Line is measured by lineal Inches, Feet, Yards, Poles, *&c.* a Superficies by superficial or square Inches, and a Solid by solid or cubical Inches: And when 'tis known how many Inches, Poles, *&c.* are contained in a Line, the length of that Line is said to be known; so when 'tis known how many square Inches are contained within a

Superficies, the Content or Area of that Superficies is ſaid to be known. And laſtly, when 'tis known how many ſolid Inches are contained within any Solid, then the Content of that is likewiſe known. But in this I preſuppoſe my Reader to be competently vers'd, otherwiſe I would refer him to the firſt Book of *Euclid*'s Elements, and to ſome others; alſo, I would adviſe him to get *Spidel*'s Geometrical Extractions, or *Newton*'s Mathematical Elements, Printed in the year 1660. in *Quarto*, the firſt Part of which is to this our purpoſe, but the two latter Parts are Aſtronomical.

2. In Arithmetick, he ought to underſtand Addition, Subtraction, Multiplication, Diviſion and the Extraction of Roots in whole Numbers, and the ſame in Fractions, both Vulgar and Decimal; but if he be to ſeek herein, let him get *Wingate*'s Arithmetick of the 5th, 6th, or 7th Edition, as 'tis enlarged by Mr. *Kerſey*.

And for his further help therein, I have here inſerted a brief Account of the Nature and Uſe of Decimal Arithmetick and Logarithms.

SECTION 1.

Notation, Addition, Subtraction, Multiplication and Diviſion in Decimals, with whole and mixt Numbers.

A Decimal is the Numerator of a Fraction whoſe Denominator is an Unit, with one or more Cyphers, which Denominator is not expreſſed, it being known by the Numerator.

For ſo many places as are in the Numerator, or Decimal, ſo many Cyphers are ſuppoſed to be adjoyned to the Unit in the Denominator. It ought to have a Point before it thus . as a Badge whereby it may be known: being otherwiſe written as a whole Number.

Therefore a Decimal of one place is Tenths, as this .2 is two tenths. Of two places is Cents or hundred parts, as this .02 Of three is Milleſmes or thouſand parts, as this .002 *&c.* The ſignificant Figures being put

put by the Cyphers into places of leſs value, and the places decreaſing from Unit in a ten-fold Proportion.

Or thus. Call ſuch as have a ſignificant figure next after the Point, as theſe .3, .25, .732, *&c.* Decimals of the firſt rank or rate. Such as have one Cypher after the Point, as theſe .08, .0134, *&c.* Decimals of the ſecond rank or rate. Such as have two Cyphers after the Point, Decimals of the third rate, *&c.* The convenience whereof you will find afterward.

The work is the ſame as in whole Numbers: yet take theſe Directions;

1. If you uſe a whole Number with mixt Numbers or Decimals; Let it have always a Point after it.

2. In Addition and Subtraction; the Points prefixt to the Decimals muſt be ſet under one another, by which means the Units in the whole or mixt Numbers ſtand alſo under one another.

3. In Subtraction, Although a Cypher at the right hand of a Decimal is of no value, (as theſe .5, .50, .500, are no more than 5 tenths, or an half) yet if the Decimals conſiſt not of an equal Number of places, or if one of the Numbers be a whole Number you muſt annex Cyphers, or ſuppoſe them annexed.

Examples of Addition.

22.75	19.2	.17	32.78	.34
9.6	4.68	.89	12.	.178
				.84
32.35	23.88	1.06	44.78	.7
				2.058

Examples of Subtraction.

22.75	19.2	107.	48.16
9.6	4.68	8.93	17.
13.15	14.52	98.07	31.16

Multiplication.

1. But in Multiplication, ſet them as if they were whole Numbers, and ſo multiply them: Cutting off from the Product found ſo many figures to the right hand, as there are places in the Decimals, both of the Multiplicand, and the Multiplier; So the reſidue is the whole part of the Product, and the figures cut off, the Decimal.

2. If the Product hath not ſo many places, as there are places of Decimal parts in both Numbers; Supply the deficient places with Cyphers prefixt to the left hand.

Examples.

46.25	87	564.	.0375	.76	21
35.	.9	.25	.05	8.	.07
23125	.783	2820	.001875	6.08	1.47
13875		1128			
1618.75		141.00			

By theſe Examples you ſee how the whole part of the Product is diſtinguiſh'd from the Decimal part thereof.

Diviſion.

In Diviſion it is ſomething harder to diſtinguiſh the whole part of the Quotient from the Decimal part thereof.

Firſt, Annex Cyphers to the Dividend, at pleaſure, or leave ſpace for them, that the Diviſion may be continued to a ſufficient Quotient. Then place the Diviſor under it according to the old way of Diviſion: but ſo as if they were both whole Numbers: Then obſerve well what place or degree of the Dividend ſtandeth over the place of Units in the Diviſor: whether

ther theſe places be real, or only ſuppoſed; of the ſame degree or place is the firſt figure in the Quotient. Which being once noted, you need not regard the Points, nor the Cyphers at either end of the Diviſor, any more; but continue the Diviſion, as if both were whole Numbers.

See here the degrees of Decimals as they ſtand in their natural order, which may be continued either way from Unit.

Thouſ.	*Hund.*	*Tens.*	*Unit.*	*Tenth pts.*	*Hund. pts.*	*Thouſ. pts.*
1000.	100.	10.	1.	.1	.01	.001, &c.

I have here ſet down ſome Examples, wherein you may ſee how the Diviſor is placed under the Dividend at the firſt Queſtion, and alſo the two firſt figures in the Quotient.

Divid.	180.000 (30. &c.	*Divid.*	1.75000 (.02 &c.
Diviſ.	5.875	*Diviſ.*	63.
Divid.	1.00000 (.083 &c.	*Divid.*	.748000 (91. &c.
Diviſ.	12.	*Diviſ.*	.0082
Divid.	9.72000 (21. &c.		
Diviſ.	.45		

In the two laſt Examples: Although there be neither Unit-place in the Diviſor, nor (if there were) any figure over it in the Dividend: yet by ſuppoſing the places continued to the left hand, or ſupplying them with Cyphers; you will ſee that the firſt place in the Quotient is the place of Tens.

I account that way of Diviſion the beſt: In which, after (upon examination by multiplying the Diviſor by the anſwering figure from the left hand toward the right) you have found the fit figure to be put in the Quotient; You proceed, in your Diviſion to multiply the Diviſor by the anſwering figure, beginning with the figure in the Diviſor next the right hand. If the

figure over it in the Dividend be not great enough to take the Product out of it; call it ſo many Tens, more than it is, as will make it great enough, but no more; and then ſubtract; ſetting the remaining figure over it, and cancel the ſaid figure: And for the Tens added, call the Product of the next figure ſo many Units more than it is. Admit the Product 36 muſt be taken out of 2; call the 2, 42: and ſubtract. Suppoſe the next Product is 18; call it 22, &c. which way you make feweſt figures: and is no more burthen to the memory, than ordinary Multiplication.

To multiply or divide any whole Number, mixt Number, or Decimal by 10, 100, 1000, &c. *by removing the Point.*

To multiply: Remove the Point ſo many places to the right hand, as there are Cyphers in the Multiplier: If figures be wanting; ſupply them with Cyphers, as here, 27. by 10, is 270.: .13 by 100, is 13.: .02 by 10 is .2.

To divide: Remove the Point ſo many places to the left hand, as there are Cyphers in the Diviſor: if places be wanting; ſupply them with Cyphers as here, 27. by 10 is 2.7.: .13 by 100, is .0013: 02 by 10, is .002.

SECT. 2.

Logarithms.

Purpoſing to give you the Solution of ſome of the Queſtions in this Book by thoſe excellent Numbers, the Logarithms; Take theſe Directions for the better underſtanding the Nature and Uſe of them.

They are Artificial Numbers fitted to the Natural, for the eaſe of Calculation. And are Printed in Tables having two Columns. One hath the Natural Number; againſt it in the other is his Logarithm: So that the Logarithm of a whole Number is eaſily found.

The

The Tables begin at 1, whose Log. is 0, 00000: and reach commonly to 10,000: consisting every one of 8 figures though, (unless in great Numbers), we seldom use above six: if the figures left out exceed 50, we put a Unit to the sixth), So *Ulacq* and *Gellibrand*. Sir *Jonas Moor* also as far: to which are annexed differences: by the help of which, and a Table of proportional parts adjoyned, you are directed to find the Logarithm of any Number to 100,000. But these are but of 7 places.

Mr. *Wingate*, in his *Tabulæ Logarithmicæ*, hath them to 100,000, with differences also: whereby making a Proportion (which is done speedily by one slip of this Rule), you have the Logarithms as far as 1,000,000; in a portable Volume for the Pocket. A Book, which I commend to any that delight in Arithmetick.

The first figure, called the Index (which is commonly seperated by a Point; better left out, except in the first hundred; as in the late Printed Tables), shews how many figures the answering Number, if whole; or the whole part thereof, if it hath a Decimal annexed, consisteth of: which are always more by one, than the Index. So 0. is the Index of one figure; 1. of two figures; 2. of three; 3. of four, &c.

Also according to the excellent way of Mr. *Christopher Townely*, cited by Sir *Jonas Moor* in his Mathematical Compendium; The Log. of a Decimal is the same, as if it were a whole Number, with this direction for the Index.

If the Decimal be of the first rate, the Index is 9; if of the second rate, the Index is 8; if of the third rate, the Index is 7, &c. Or, the Index is the Complement of the rate to Ten. *Viz.* of the distance of the first significant figure to the left hand, from the point or Unit: Which, I hope, you will understand, if you observe this following Table.

Where

Where you see, That in the Perfect Numbers, the Index sheweth the Number of places in the whole Numbers, and in the whole part of the mixt, being always less by one, than the said places; but in Decimals, it sheweth the Rate, being the Complement thereof to Ten, not regarding the number of places.

Perf. Numb.	*Logs.*
3536.	3.54851
353.6	2.54851
35.36	1.54851
3.536	0.54851
Decimals.	*Logs.*
.3536	9.54851
.03536	8.54851
.003536	7.54851
.0003536	6.54851

If then you would have the Log. of any Number, find the Log. thereof in the Table, as if it were whole: and prefix the Index answering the value.

And having a Log.; find the Number answering in the Table; and by a Point fix the value according to the Index.

To find a Log. to a Number of six places in the Tabulæ Logarithmicæ *by help of this Rule.*

Call the Differences at the bottom the Tabular Differences. Having the Log. of the five first figures, by the double Scale on your Rule, set 10 to the Tabular Difference; against your sixth figure is his proportional part to be added to the Log. before found.

To find a Number of six places answering a Log. given.

Find the Number of five places answering the Log. in the Table, next less to the given Log, subtract the said Log. out of the given Log. call the remain the proper Difference, then by the double Scale on your Rule, set 10 to the Tabular Difference; against the proper Difference on the second, is your sixth figure on the first.

Note, That you must use all the eight figures in this case.

Some

Some Uſes of the Logarithms.

Whereas, before the aforeſaid contrivance of the Indices by Mr. *Townly*; if one Number were perfect, and the other a Decimal, there was a different Rule in every operation for them: But by the ſaid contrivance, one is now ſufficient; I will give Examples only, in which one Number is a Decimal: with theſe two Directions.

1. In the Log. which anſwereth the Queſtion (whether it be a Sum, Remainer, Half, *&c.*) If the Index be Ten or above, neglect or cancel the ſaid figure in the place of Tens.

2. Where you are ordered to ſubtract a greater Log. out of a leſs; Add ten to the Index of the leſs, and then ſubtract.

1. *Multiplication.*

Add the Logs. of the two, or more Numbers to be muitiplied; the Sum is the Log. of the Product. So 12 multiplied by the Decimal ,25; the Product is 3.

	12.	1.07918
By	.25	9.39794
	3.	0.47712

It may alſo be done, where there are but two, by ſubtracting the Arithmetical Complement of the Log. of one of them out of the Log. of the other; The remainder is the Log. of the Product.

Which Arithmetical Complement is the remainer of every figure, (including the Index), to 9; except of the laſt ſignificant figure to the right hand, whoſe remainer you muſt take to Ten. As in theſe three Examples.

Numb.		
2.	0.30103	*Log.*
.5	9.69897	*Ar. Compl.*
Numb.		
80.	1.90309	*Log.*
.0125	8.09691	*Ar. Compl.*
Numb.		
100.	2.00000	*Log.*
.01	8.00000	*Ar. Compl.*

2. *Diviſion.*

2. *Division.*

Subtract the Log. of the Divisor out of the Log of the Dividend (whether of the two be greater or less); The remainer is the Log. of the Quotient. So 12 divided by the Decimal .25; The Quotient is 48.

12.		1.07918
By .25		9.39794
48.		1.68124

It may also very conveniently be done, by adding the Ar. Compl. of the Log. of the Divisor to the Log. of the Dividend; The Sum is the Log. of the Quotient, as followeth.

3. *The Rule of Three Direct.*

1. Add the Logarithms of the second and third, from the Sum subtract the Log. of the first; the remainer is the Log. of the fourth.

2. A better way: Add the Ar. Compl. of the Log. of the first to the Logarithms of the second and third; The Sum is the Log. of the fourth. *Example.* If .25 give 16.; What shall 12. give?

Answer, 768.

Ar. Compl.	.25	0.60206
	16.	1.20412
	12.	1.07918
	768.	2.88536

But in the Inverse Rule: Add the Ar. Compl. of the Log. of the third to the Logarithms of the first and second; the Sum is the Log. of the fourth. Thus are resolv'd the Questions wrought on the double Scale.

But for those in this Book, where there is a duplicate proportion, as in Timber-Measure and Gaging: If the first and third Numbers be on the Square Line, There are general or fixt Logarithms belonging to the first Numbers; to which if you add the Log. of the second, and the Log. of the third twice, the Sum of all four is the Log. of the fourth.

If the second and fourth Numbers be on the Square Line: To the Ar. Compl. of the Log. of the first add the Log. of the third, and the Log. of the second

ſecond twice; Half the Sum is the Log. of the fourth.

4. *The Square Root.*

Half the Log. of the Number given is the full Log. of the Square Root.

If the Number be a Decimal, add ten to the Index, and then halve it, as here.	.25	19.39794
	.5	9.69897

5. *The Cube Root.*

The third part of the Log. of the Number given is the full Log. of the Cube Root.

If the Number be a Decimal, add twenty to the Index, and then divide by 3, as here.	.25	29.39794
	.63	9.79931

6. *To find a mean Proportional between two Numbers.*

Add their Logs together: Half the Sum is the Log. of the mean Proportional.

When one is a Decimal, If the Sum of the Indices be ten (as here), or above; caſt away ten, and then halve it: if it be not ten, add ten to it, and then halve it.	12.	1.07918
	.25	9.39794
		10.47712
	1.732	0.23856

7. *To find two, or more, mean Proportionals between two Numbers.*

This, in caſe of a Decimal, was ſomething perplex't, as you may ſee in Mr. *Wingate*'s Artificial Arithmetick. It is now, by the aforeſaid contrivance of Mr. *Townly*, as eaſie, as it is uſeful.

Subtract the Log. of the leſs Number out of the Log. of the greater: The remainer divide by a Number greater by one, than the Number of means ſought; as here by 4 for three means.	12.	1.07918
	.25	9.39794
		1.68124
		42031

This

This Quotient added to the Log. of the leſs Number; The Sum is the Log. of the firſt mean. To which adding again the ſaid Quotient; The Sum is the Log. of the ſecond mean. And ſo forward for as many means, as the Quotient was at firſt ordered for.

	Means.	
		9.39794
		42031
1	.658	9.81825
		42031
2	1.732	0.23856
		42031
3	4.556	0.65887

8. *To find the Log. of a Vulgar Fraction.*

Subtract the Log. of the Denominator out of the Log. of the Numerator; The remainer is the Log. of a Decimal equivalent to the ſaid vulgar Fraction.

	0.47712
$\frac{3}{4}$	0.60206
.75	9.87506

9. *To find the Log. of a Number with a Vulgar Fraction annex'd.*

Change the Number into an improper Fraction, by multiplying the whole Number by the Denominator of the Fraction, and adding the Numerator to the Product; The Sum is the Numerator of the improper Fraction.

Then ſubtract the Log. of the Denominator out of the Log. of the Numerator, as before; The remainer is the Log. of the ſaid Number with a Decimal, equal to the ſaid Vulgar Fraction, annex'd.

	12. $\frac{1}{4}$
$\frac{49}{4}$	1.69020
	0.60206
12.25	1.08814

I have, as an Appendix to this part, adjoyned the uſual Decimal Tables, and compriſed them into five: Yet the uſe of them is as eaſie, as if they were all ſingle.

The Integers, or wholes, are ſet on the Top: and the parts follow in order, with their Decimals annexed.

A TABLE

TABLE I.

A TABLE of Engliſh Coin, *a Pound ſterling* } *Integer.*
Alſo Troy Weight, *an Ounce* }

Shillings and Peny weight.	Decimals.	Pence with Farthings.	Decimals.	Grains.
19	.95	3	.0489583	
18	.9	2	.0479166	23
17	.85	1	.046875	
16	.8	11	.0458333	22
15	.75	3	.0447916	
14	.7	2	.04375	21
13	.65	1	.0427083	
12	.6	10	.0416666	20
11	.55	3	.040625	
10	.5	2	.0395833	19
9	.45	1	.0385416	
8	.4			
7	.35	9	.0375	18
6	.3	3	.0364583	
5	.25	2	.0354166	17
4	.2	1	.034375	
3	.15	8	.0333333	16
2	.1	3	.0322916	
1	.05	2	.03125	15
		1	.0302083	
		7	.0291666	14
		3	.028125	
		2	.0270833	13
		1	.0260416	
		6	.025	12
		3	.0239583	
		2	.0229166	11
		1	.021875	

The Reſidue of the Table.

Pence with Farthings.	Decimals.	Grains.
5	.0208333	10
3	.8197916	
2	.01875	9
1	.0177083	
4	.0166666	8
3	.015625	
2	.0145833	7
1	.0135416	
3	.0125	6
3	.0114583	
2	.0104166	5
1	.009375	
2	.0083333	4
3	.0072916	
2	.00625	3
1	.0052083	
1	.0041666	2
3	.003125	
2	.0020833	1
1	.0010416	
½	.0005208	

TABBE II.

Averdupois *great Weight*, *One Hundred at* 112 l. *Integer.*

Quarters.	Decimals.
3	.75
2	.5
1	.25

Pounds.	Decimals.
27	.2410714
26	.2321428
25	.2232143
24	.2142857
23	.2053571
22	.1962286
21	.1875
20	.1785714
19	.1696428
18	.1607143
17	.1517857
16	.1428571
15	.1339286
14	.125
13	.1160714
12	.1071428
11	.0982143
10	.0892857
9	.0803571
8	.0714286
7	.0625
6	.0535714
5	.0446428
4	.0357143
3	.0267857
2	.0178571
1	.0089286

The Residue of the Table.

Ounces.	Decimals.
15	.0083705
14	.0078126
13	.0072545
12	.0066964
11	.0061384
10	.0055803
9	.0050223
8	.0044643
7	.0039062
6	.0033482
5	.0027902
4	.0022321
3	.0016741
2	.0011161
1	.000558

Quarters.	Decimals.
3	.0004185
2	.000279
1	.0001395

TABLE III.

Averdupois *little Weight, one Pound* } *Integer.*
Long Measure, one Yard or Ell }

Ounces.	Decimals.	Qtrs with Nails.
15	.9375	3
14	.875	2
13	.8125	1
12	.75	3
11	.6875	3
10	.625	2
9	.5625	1
8	.5	2
7	.4375	3
6	.375	2
5	.3125	1
4	.25	1
3	.1875	3
2	.125	2
1	.0625	1

The Residue of the Table.

Drams.	Decimals.	Qtrs of Nail.
15	.0585937	
14	.0546875	
13	.0507812	
12	.046875	3
11	.0429687	
10	.0390625	
9	.0351562	
8	.03125	2
7	.0273437	
6	.0234375	
5	.0195312	
4	.015625	1
3	.0117187	
2	.0078125	
1	.0039062	

Quarters.	Decimals.
3	.0029297
2	.0019531
1	.0009765

TABLE IV.

Liquid Measure, one Galon } *Integer.*
Dry Measure, one Quarter }

Pints.	Decimals.	Bushels.
7	.875	7
6	.75	6
5	.625	5
4	.5	4
3	.375	3
2	.25	2
1	.125	1

Quarters.	Decimals.	Pecks.
3	.09375	3
2	.0625	2
1	.03125	1

1	Decimals.	Quarters of a Peck.
	.0234375	3
	.015625	2
	.0078125	1

	Decimals.	Pints.
	.0058594	3
	.0039063	2
	.0019531	1

TABLE V.

Dozens, one Gross } *Integer.*
Time, one Year }
Long Measure 1 Foot }
Pence, one Shilling }

Dozens. Months.	Decimal.	Inches. Pence.
11	.9166667	11
10	.8333333	10
9	.75	9
8	.6666667	8
7	.5833333	7
6	.5	6
5	.4166667	5
4	.3333333	4
3	.25	3
2	.1666667	2
1	.0833333	1

Parts.	Decimal.	Quarters and Farth.
11	.0763889	
10	.0694444	
9	.0625	3
8	.0555555	
7	.0486111	
6	.0416667	2
5	.0347222	
4	.0277778	
3	.0208333	1
2	.0138889	
1	.0069444	

Days belonging to the Table of Time.

Days.	Decimals.	Days.	Decimals.
30	.08219178	15	.0410959
29	.079452	14	.0383562
28	.0767123	13	.0356164
27	.0739726	12	.0328767
26	.0712329	11	.030237
25	.0684931	10	.0273972
24	.0657534	9	.0246575
23	.0630137	8	.0219178
22	.060274	7	.0191781
21	.0575342	6	.0164383
20	.0547945	5	.0136986
19	.0520548	4	.0109589
18	.0493151	3	.0082192
17	.0465753	2	.0054794
16	.0438356	1	.0027397

To bring Decimals into known Parts.

Multiply the Number of parts in one Integer, and the Decimal together: From the Product cut off so many Figures to the right hand as are in the Decimal (as you are directed in Multiplication of Decimals) The residue to the left hand are the parts sought: and the Figures cut off are a Decimal of one of those parts, to be reduced the same way into the next less parts, if there be any, or if there be need. If nothing be left to the left hand; there is not one of those parts in that Decimal: Therefore account it cut off, and proceed to find the next less parts, as before.

The making these Tables is by dividing the Numerator of the Vulgar Fraction, which represents the parts, by the Denominator; The Quotient is the Decimal. So $\frac{11}{20}$ being the vulgar Fraction of Eleven Shillings or Penny weight: If you divide 11 by 20; The Quotient ,55 is the Decimal: So that half the Number of Shillings or Penny weight is the Decimal. Also $\frac{26}{960}$ being the vulgar Fraction of 6 *d.* $\frac{1}{2}$, or of 26 Farthings: If you divide 26 by 960; The Quotient ,0270833, &c. is the Decimal.

Yet you shall not need Division for every Decimal; for some are found by halving the Integer or 1: and so continually: So are found the Decimal of one half, one quarter, one half quarter, &c. Some are found by halving a Decimal before found: So half the Decimal of a Shilling is the Decimal of Six pence: half of that, the Decimal of three pence, &c. Also one third part of the decimal of a shilling, is the decimal of four pence, and the half of that, the decimal of two pence, &c. and the double of it the decimal of eight pence. Likewise the Sum of two decimals is the decimal of the Sum of the two Fractions, whose decimals they are: and the difference is the decimal of their difference.

Some of these are of one place, and some of more: Few Tables have them to above seven: and most ordinary questions may be resolved to a sufficient exactness, if you use but four: remembring the direction above given, *viz.* If the first figure of those left out exceed 5; to add a unit to the last of those you retain.

If the answer of a question be in Money; Three places of Decimals give it to near a Farthing, as is shewn after *Part* 4. *Prop.* 5.

Now for the use of them in a question or two.

1. At 5 *s.* 3 *d.* $\frac{1}{2}$ the Ounce; what cost 7 Ounces, 3 penny weight and 19 grains.

Having added the Decimals of the parts, the question will stand thus: o *l* o *l*

1 : 0.2645833 :: 7.1895833 : 1.9022

The

The Product or Anſwer is 1 *l.*9022 &c. Which is 1 *l.* 18 *s.* 0 *d.* 2 *f.* near.

If you leave out the three laſt figures in each Decimal, with the condition above-mentioned; The Numbers are 0 *l.* 0

1 : 0.2646 :: 7.1896,

And the anſwer is 1 *l.*9023 &c. differing from the other inconſiderably.

2. To compute ſimple Intereſt for any Sum, Rate, and Time. Having put the parts, if there be any, into their Decimals: Multiply the Principal and the Rate; from the Product cut off the due Decimal, if any, and two places more for the Diviſion by 100; This Product ſo ordered is the Intereſt due for one year: which if you multiply by the time (be it more or leſs than a year) The Product (the due Decimal cut off) is the Intereſt for that time.

Examp. 1. What is the Simple Intereſt of 132 *l.* 07 *s.* 6 *d.* for 2 *y.* 3 *m.* 22 *d*, at 6 *l.* in the hundred?

The Decimal of 7*s.* 6*d.* is .375: which being annexed to the whole pounds, the principal will be 132*l.*375: which multiplyed by 6, and the Product ordered, as directed, it will be 7.9425, or 7 pounds 18 ſhillings and 10 pence farthing near, for the Intereſt for one year. But that being not the Sum ſought; Multiply the ſaid 7.9425 and the time, *viz.* 2*y.*3103; The Product 18.3493 is the Intereſt ſought, *viz.* 18 *l.* 06 *s.* 11 *d.* 3 *f.*

Ex. 2. What is the Intereſt of the ſaid Sum for two Months and ten Days at the ſame rate? Multiply the ſaid 7.9425 by .1941 the Decimal of the time; the Product 1 *l.* 5416 or 1 *l.* 10 *s.* 10 *d.* is the Intereſt ſought.

But the great convenience of Decimals is, that their Logs, are ſo eaſily found; as is already ſhewn in this ſecond Section. So that by the *Tabulæ Logarithmicæ* mentioned in the afore cited place, any queſtion, whoſe Numbers (whether Whole, Mixt, or Decimals) exceed

ceed not six places, may be speedily resolved: Mr. *Townley*'s Indices of the Decimals freeing us from the perplexity of different Rules. As in the two last Examples.

To the Arith. Compl. of the Log. of 100 *viz.* 8.0000000 Add the Logs. of the principal and of the rate; The Sum is the Log. of the Interest for one year. To which Log. if you add the Log. of the time; This Sum shall be the Log. of the Interest for the Time.

Example 1.

100.	*Ar. Compl.*	8.
132.375		2.1218059
6.		0.7781512
7.9425		0.8999571
2.3103		0.3636683
18.3495		1.2636254

Example 2.

100.	*Ar. Compl.*	8.
132.375		2.1218059
6.		0.7781512
.1941		9.2880255
1.5416		0.1879826

Or without seeking the Interest for one year: To the said Ar. Compl. Add the Logs of the Principal, rate, and time; The Sum shall be the Log. of the Interest demanded, as in the second Example.

3. Compound Interest for any Principal, rate, and time by the Logarithms.

In this Proposition the excellency of those Numbers appears: such Questions being resolved by them with great ease and speed: but by Natural Arithmetick not without considerable time and trouble.

Deduct the Log. of 100 from the Log. of 100 and the rate added together, as 105, 106 &c.: The difference multiply by the time: From the Product cut off the Decimal, if there be any: The Remain. Add to the Logarithm of the Principal; The Sum is the Logarithm of the Principal and Interest required.

Example

Example.

Let the Principal, rate, and time be as in the former of the two laſt Queſtions. Perſuing the rule, as you ſee in the Margin; The Sum of the principal and compound Intereſt is 151*l.* 09*s.* 00*d.*

The Difference	253058
The Time	2.3103
The Product	584639.8974
132.375	2.1218059
	584639
151.45	2.1802698

It ſeems by this, that the Intereſt of 100 *l.* at 6 *l. per cent.* by the Year, is not fully amounted to 3 *l.* in 6 Months: for if you multiply the aforeſaid difference by .5, the decimal of 6 months; and, having cut off one place, add the reſidue to the Log. of 100; The Sum will be 2.0126529: Which is the Log. of 102.956, that is 102 *l.* 19*s.* 01 *d.* 1 *f.*

I will add two or three Examples more, which I hope will be ſufficient.

1. What is the value of 28 Ounces 6 penny weight and 15 grains of Gold, at 3 *l.* 3 *s.* 6 *d.* the Ounce? Annexing the Decimals to the Integers, the Numbers ſtand thus,

o.	*l.*		o	*l.*
1	: 3.175	::	28.33125	: 89.952.

	l.	*s.*	*d.*	*f.*		
Facit,	89	19	00	2.	3.175	0.5017437
					28.33125	1.4522657
					89.952	1.9540094

o.	*p.*	*gr.*		*l.*	*s.*	*d.*
2. If 4	9	12	of Gold coſt	14	10	9;

What is that the Ounce?

	o.	*l.*		o.	*l.*
The Numbers are	4.475	: 14.51875	::	1	: 3.2444

	l.	*s.*	*d.*	*f.*	4.475	*Ar. Compl.*	9.3492070
Facit,	3	04	10	2.	14.51875		1.1619291
					3.2444		.5111361

3. At

3. At 6 *s.* 3. *d.* the Ounce; how much Silver Plate will 5 *l.* 3 *s.* 6 *d.* Buy?

	l.	*o.*	*l.*	*o.*
The Numbers are	0.3125	: 1 ::	5.175	: 16.56

o. p. gr.	.3125	*Ar. Compl.*	0.50515
Facit, 16: 11. 05 near.	5.175		0.71391
	16.56		1.21906

I have taken but 6 figures in this last Example. If I had used no more in the other, the difference would have been little or inconsiderable: as you may find if you please to give your self that small trouble.

These thus premised, I shall come next to the Description and Uses of the Rule in several Measures. Wherein I shall use these Vulgar Fractions, *viz.* $\frac{1}{4}$ one quarter: $\frac{1}{2}$ one half: $\frac{3}{4}$ three quarters. The Decimals belonging to these, as they are immediate parts of the whole, are .25 for a quarter: .5 for an half: and .75 for three quarters.

But if they be parts of parts; other decimals belong to them, as you see in the Tables.

The Art of Practical Measuring *easily Performed*, &c.

Part II.

The Description of the Rule.

UPon each Flat or Side of the Rule are four Lines, two next the outward edges, which are Lines of Measure; and two next the inward edges, which are Lines of Proportion.

One side (as in *Fig.* I.) next the outward edges, hath a Line of Inches divided into Halfs, Quarters, and Half Quarters, and figured from 1 to 12 on one piece of the Rule, and from 12 to 24 on the other. Next the inward edges upon one piece, is a Line of Numbers in two lengths; The first from 1 at the beginning, to 1 in the middle; The second from 1 in the middle, to 10 at the end. On these Rules it is thus divided, between 1 and 2 into 10 parts and each tenth is again subdivided into 5 parts, from 2 to 3 the same, from 3 to 4 into 10 and each tenth into 2 parts, and so on from 4 to 6, from 6 to 7 into 10 parts only, and so on to 1 in the middle: and the second Radius is divided exactly like the first. But I have had some Rules that have been more nicely subdivided, *viz.* from 1 to 3 each part into 100, and from 3 to 6 each part into 50, and from 6 to 10 each part into 20.

Upon

Upon the other piece next adjoyning to the Line of Numbers, is a Line which I call the Square Line, and (when the Measure of round Timber is concern'd) the Girt Line, which Line is figured thus 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, this from 4 to 10 has each tenth divided into 2 parts, and from 10 to 40 into 4 parts, also the divisions 38 and 39 with their halfs and quarters, are put on before 4 at the beginning of this Line, and cut as in their proper places.

On the other Flat (*Fig.* II.) next the outward edges, on one piece, is a Line of Inches divided each into 10 parts for Gauging, *&c.* on the other, a Foot divided into 100 parts, and this I mean when I mention Foot Measure, the beginnings of both these Lines are at the ends of the Rule, the ends, at the broad loop or middle, when the Rule is set to two Foot.

Next the inward edges are two Lines of Numbers divided exactly as that on the other side, and these are called in this Book the *Double Scale.*

That piece to which the Brass loops are riveted, I call the *Fixt Rule*, the other the *Moveable.*

SECTION I.

Of the Line of Numbers, commonly called Gunter's *Line.*

The proper Numeration of this Line I account, 1 at the beginning: and so by 10 in the middle, to 100 at the end.

But for the better understanding this Line: See here the Degrees of Number from Unit on either side, as they stand on the Line: That is increasing from left hand to right.

Thous. pts.	*Hund. pts.*	*Ten. pts.*	*Unit.*	*Tens.*	*Hund.*	*Thous.*
.001	.01	.1	1.	10.	100.	1000.

Where you see, how they increase on one side from Unit, and on the other side decrease from the same

in

in a Tenfold Proportion. So that if you ſet any one of them at the beginning; the two next following ſhall be, one the middle, the other the end. As if you call 1 at the beginning one tenth; the middle ſhall be 1, and the end 10. If you call 1 at the beginning 10; the middle ſhall be 100, and the end 1000. But if it be not otherwiſe limited; account it, as I ſaid before, 1, 10, 100.

On that Line of Numbers, which is on the moveable Rule, at theſe Numbers following may be Pricks, for the more ready finding them: They being firſt Numbers or Centers, as they commonly call them.

At 9, for Yard-Meaſure.

At 125 four Points thus . ˙ ˙ ., for Plank or Board, and Glaſs.

At 144, alſo for Glaſs.

At 160, for Land-Meaſure.

At 272, (for the Decimal .25 may be omitted without conſiderable errour) for Rod-Meaſure of Brick-Wall at 1 ½ Brick thick.

At 204; for two Brick thick, and other Points or Cuts for other thickneſſes, if deſired. The finding whereof is ſhew'd after.

At 282 for Ale-galon-Meaſure in Square and Oblong Veſſels. And other may be ſupplied, as any hath occaſion for them.

SECT. 2.

Of the Square or Girt-line.

This is no more but one whole length of the Line of Numbers; but at a double Radius: it being exactly equal to the Lines of Numbers on this Rule, which are in two lengths.

In the Numeration of it, when occaſion requires, you muſt account 10, 20, 30; to be 1, 2, 3: as alſo 4, 5, 6, 7, &c. to be 40, 50, 60, 70, &c.

At 12 on this Line, let there be four Pricks, as at 12 on the Line of Numbers: At 17. 15 the Wine-Point, marked W. At 18. 95 the Ale-Point, marked A. These are put on by the Workman.

At 10. 635 may be a Point like the Gauge-Points, for finding the true content of a round Solid by the Girt.

At 13. 54 such another, for finding the Content of a Cylinder by the Diameter.

At 41.57 another, to shew how many Inches in length make a Foot solid at any Girt or Square not exceeding 40 Inches.

These may be put on thus:

For the first: Set 12 on the Square-line to 14 on the Line of Numbers; against 11 on the Line of Numbers mark this Point.

The second: Set 12 on the Sq. Line to 11 on the Line of Numbers; against 14 on the Line of Numbers mark this Point.

The third: Set 12 on the Sq. Line to 1 at the beginning of the Line of Numbers; against 12 on the Line of Numbers mark this Point.

These, or any other mentioned hereafter, cut with a sharp-pointed Pen-knife in two places, as the Gage-Points, and strike in with your finger, some Sallow-cole fine ground with Linseed-Oil; and then wipe the Rule clean.

Both these Lines are put on from the Logarithms,

SECT. 3.

The general Use of Double Scales.

It is chiefly for the working the Rule of Three: or having three Numbers given to find a fourth Proportional. It including Multiplication and Division: for there is no other difference, than that in these two an Unit is one of the three.

To

To find this fourth: Set the first Number on the first Rule, to the second Number on the second Rule; against the third Number on the first Rule is the fourth on the second Rule.

Example. If 2 give 3; what shall 6 give? Set 2 on the first, to 3 on the second; against 6 on the first, is 9 on the second.

Wherefore when I say, Set 2 to 3; against 6 is 9: I mean as in the above-set Example, though I name not the first or second Rule. Yet you may note, that the *moveable* or *longer Rule* is, for the most part, the *first*; whether side soever of the two you work on.

So in Multiplication; 1 being the first Number; Set 1 to either of the two Numbers to be multiplied; (best to the nearest) against the other is the Product.

In Division; The Divisor being the first Number: Set it either to 1, or to the Dividend; against the other is the Quotient. Examples of both you will meet with after.

By this the Arithmetick of the Rule is easily understood: the first Numbers being Divisors. Only where the Sq. Line is used; the Numbers on the Sq. Line must be squared, or multiplied by themselves: and their Squares used in every respect, as if they were the Numbers themselves, as you will after see.

SECT. 4.

To set the Square-Line to his Squares, and thereby, To Square a Number not exceeding 100, *and to find the Square root of a Number not exceeding* 10, 000.

1. Set 10 on the Sq. line to 1 at the beginning of the Line of Numbers: both which if you account 1; you have, on the Line of Numbers, the Squares from 1 to 16. Also at this set it is most convenient to take the Squares from 1000 to 1600; *viz.* by accounting 10 on the Sq. line 10, and 1 at the beginning 100.

2. Set 10 on the Sq. line to 1 in the middle, accounting 10 on the Sq. line 10, and 1 in the middle 100; you have the Squares on the Line of Numbers from 16 to 1000; and of this you will have moſt uſe.

3. Set 10 on the Sq. line to 10 at the end, accounting 10 on the Sq. line 100, and 10 at the end 10,000: So have you on the Line of Numbers the Squares from 1600 to 10,000: And againſt all the Squares, at every ſet, his own root.

Examp. I would know what is the Sq. root of 380. Set 10 on the Sq. line to 1 in the middle; (according to the ſecond Direction) againſt 380 on the Line of Numbers is 19.5 near.

SECT. 5.

A Direction concerning the ſhortneſs of the Lines on the Rule.

1. On the Double Scale: If you uſe half of either the ſecond or third Number inſtead of the whole; you will have half the content. If you uſe the half of both; you have only a quarter of the content. The firſt muſt remain whole.

2. On the Sq. line-ſide: If you uſe half that Number, that is on the Line of Numbers, commonly the ſecond; (being ordinarily lengths or depths) you have half the content.

If half of that on the Sq. line, commonly the third; (being ordinarily Sides of Squares, or Diameters) you have a quarter of the content. If you halve them both; you have only one eighth of the content.

3. In finding a mean Proportional: half the extremes give half the means: and a quarter gives a quarter. Theſe may be more exactly defined, and multiplied accordingly.

This Direction alſo may be uſeful to you in working by the Sq. line, when at any time the third Number ſtandeth beyond the Line of Numbers: and removing the firſt to the ſecond in the other length, ſets it farther off. For then, 1. If

1. If the first be a fixt Number on the Sq. line; as 12, and the Gage-Points, *&c.* Set it to half the second; and double the content.

2. If the first and second be fixt, as in finding the superficial content by the Diameter, use half the third Number being on the Sq. line, and quadruple (or multiply by 4) the content;

These Products are the fourth Numbers sought.

The Art of Practical Measuring *easily Performed*, &c.

Part III.

PROP. I.

To Measure Round Timber the common Way.

MEasure the length in feet and half feet: and (if the Custom or Agreement be so) in Quarters; Then back again half way, where Girt the Tree with a small Cord or Chalk-line: Double this Line twice very even. This fourth part of the Circuit (which in this Treatise I call the Girt) Measure in Inches, Halves, and Quarters of Inches. And this observe, That the lengths be given in feet: the Girts and sides of Squares in Inches.

So have you three Numbers given, *viz.* 12 always the first: the length always the second, and the Girt or side of the Square the third.

To come now to the Rule: Set 12 on the Girt-line to the length on the Line of Numbers; against the Girt on the Girt-line is the content on the Line of Numbers. And this is the general Rule.

Now there being two Cases: One, when, at the first set, the Girt is against some part of the Line of Numbers: The other, when it is not, so that 12 must

must be removed; I will give you several Examples of both. Observing, that the Vulgar Fractions before-mentioned; as also all Decimals, always follow the Number they belong to, before the name thereof.

Case 1.

Examples.

1. A Tree is 20 f. long; and 15 inches Girt: Set 12 to 20.; against 15. is 31. ¼ f. or 31 f. and a quarter.

2. A Length is 8 ½ f. The Girt is 35 ¾ inches. Set 12 to 8 ½; against 35 ¾ is 75 f. and almost an half.

3. A length is 15 f. The Girt 42 ½ inches: Set 12 to 15; against 42 ½ is 188 f.

4. A Rail is 15 f. long: The Girt 3 inches: Set 12 to 15; against 3 is 9 tenths of a foot, and more.

5. A length is 9 ½ f. The Girt 39 ¾ inches: Set 12 to 9 ½; against 39 ¾ at the beginning of the Girt-line is 104 f.

6. The length is 0.62 f. The Girt 35 inches: Set 12 to the Decimal .62 in the first length; against 35 is 5 ¼ f. which may serve for a short cut of a Tree.

If this length had been propounded 7 ½ inches: It must have been turned into Foot-measure thus: On the double Scale: Set 12 to 100; against the length in inches is the length in foot-measure: but if it lies before you; measure it by the Line of foot-measure on the Rule.

Case 2.

If at the first Set, the Girt is beyond the Line of Numbers; remove 12 to the length in the other length thereof. Which case may also happen in Gauging, *&c.*

Examp. 1. The length is 18 f. The Girt 31 inches: Set 12 to 18 in the first length; against 31 is 120 f.

2. A Rail is 15 f. long, The Girt 3 ½ inches: Set 12 to 15 in the first length; against 3 ½ is ¾ f: and a little more, *viz.* 1.27 f.

3. A wrong is $6\frac{1}{2}$ f. long: and $4\frac{1}{4}$ in Girt: Set 12 to $6\frac{1}{2}$ in the second length; against $4\frac{1}{4}$ is above eight tenths of a foot. These Examples may be sufficient.

Note 1.

If you would find the content of a great piece of Timber immediately in loads at 40 f. to the load; use half the Girt instead of the whole. *Example.* A length is 15 f. The Girt 42 $\frac{1}{2}$ inches. Set 12 to 15; against $21\frac{1}{4}$ is 47: whereof the 4 is 4 loads, and the 7 is 28 f.

By this way (if your Rule be not subdivided as before) you measure Timber, whose Girt is above 40 inches: as also the piece in *Case* 1. *Ex.* 5. which without the said subdivisions, and placing 38 and 39 before 4 at the beginning, are not resolved by the general Rule.

But if you would have the content of these pieces in feet. Multiply the content found, by 4 the square of 2, by which you divided your Girt; So 47 multiplied by 4 is 188 f.

Note 2.

To what length so ever you set 12; 17 will stand to the double thereof, $8\frac{1}{2}$ to half thereof, both a little over: Also 24 will stand to the quadruple thereof, and 6 to a quarter thereof exactly: and the same proportion the content bears to the length at any of these Girts: *viz.* at 17 inches Girt; the content is double to the length: at $8\frac{1}{2}$ inches Girt; the content is but half the length, *&c.*

Note 3.

If you would find these contents by Natural Arithmetick: seeing 12 and the Girt, *viz.* the first and third Numbers are on the Square-line: According to a hint given in *Sect.* 3. of *Part* II. Multiply the Square of the Girt

Girt by the length; and divide the Product by 144 the Square of 12; which is your conſtant Diviſor; The Quotient is the content.

So in *Ex.* 1. *Caſe* 1. the Square of 15. *viz.* 225. multiplied by 20; and the Product 4500, divided by 144 the Square of 12; the Quotient is 31.25 the content.

By the Logs. To this general Log. 7.84164, Add the Log. of the length and the Log. of the Girt twice; The Sum is,	*Gen. Log.*		7.84164
	20		1.30103
	15	1.17609	
		1.17609	
The Log. of the Content.	31.25		1.49485

PROP. II.

True Meaſure of Round Timber or Stone by the Girt.

Becauſe this common way of Meaſuring round Timber giveth not a true Content, but always too little (though it ſtill be generally uſed) I have given you a point, and ſhewn, how you may put it on the Rule: which ſetting to the length inſtead of 12; the Girt ſhall point you out a true Content, accounting it a Cylinder, as the ſaid common way alſo doth.

Examp. Let the length be 10 f. the Girt 15 inches: Set the ſaid point (which you may call the true point) to 10; againſt 15 you have 20 f. leſs by about one tenth: whereas the common way giveth but 15 f., and a little above an half.

The general Log. anſwering this point is 7.94652 to be uſed as before.

Thus far by the Length and Girt: I ſhall only add; that the common Meaſure is to the true, as 11 to 14. So that if you ſet 11 on the double Scale to any Number of Feet or Loads meaſured the common way; 14 ſhall point to the true content of the ſame: and if you ſet 14 to any true content; againſt 11 is the content the common way.

PROP.

PROP. III.

Having the length of a Cylinder in Feet, and the Diameter in Inches; to find the content in Feet.

Set the point 13.54 to the length; againſt the Diameter is the content. *Examp.* Let the length be 10 f. and the Diameter 20 inches: Set 13,54 to 10; againſt 20 is 21.82 f. The gen. Log. is 7.73676 to be uſed as before.

PROP. IV.

Having the length of a Square ſolid in Feet, and the ſide of the Square in Inches, to find the content in Feet.

Set 12 to the length; againſt the ſide of the Square is the Content. The Caſes are as in round Timber. The Examples alſo will ſerve, accounting the Girt to be ſides of Squares.

PROP. V.

To find a mean Proportional between two Numbers.

Set the greater of the two Numbers on the Sq. line to the ſame on the Line of Numbers; againſt the leſs on the Line of Numbers is the mean proportional on the Sq. Line.

Or, ſet the leſs on the Sq. line to the ſame on the Line of Numbers; againſt the greater on the Line of Numbers is the mean proportional on the Sq. line. One of theſe will not fail. Examples follow in the next.

PROP. VI.

Unequal Squared Solids.

Meaſure the length in Feet: The breadth and depth in inches. Then find a mean proportional between the breadth and depth, as is taught next following.

It is the side of a Square equal to the Base or end: which having found; measure the piece as square Timber.

1 *Examp.* In Timber, whose length let be 10 f. The breadth 21 in. The depth 8 ½ in. Set 21 to 21; against 8 ½ on the Line of Numbers is 13.36: or 13 a quarter and half quarter near. Or set 8 ½ to 8 ½; against 21 on the Line of Numbers is the said 13.36: Then setting 12 to 10; against 13.36 is 11.4 f.

2 *Examp.* In Stone, which let be 6.35 f. long: 36 ½ in. broad: and 5.7 in. deep. Set 36 ½ to the same; against 5.7 on the Line of Numbers is 14, and something short of an half. Then set 12 to 6.35; against this mean is 9.2 f. near.

This mean, in case of a Fraction, shall give you no trouble: For if with a Pencil, Chalk, or any thing that may be wiped out without damage to your Rule (let it not be Ink) you make a fine mark on the Sq. line at this mean; and then set 12 to the length; this mark, without defining it, shall point out your content.

PROP. VII.

Solids of a Triangular Base.

Find a mean proportional between the Base and half the Perpendicular: or between the Perpendicular and half the Base, both measured in inches. This mean is the side of a Square equal to the Triangle. Then set 12 to the length in feet; against this side is the Content.

If two sides of a Triangle be equal; the unequal side may be the Base. If the three sides be unequal; the longest side is commonly the Base: From whence the nearest distance to the opposite angle is the Perpendicular.

PROP.

PROP. VIII.

Solids whose Bases have many equal Sides and equal Angles.

These Bases are regular Figures. Having the length in Feet: and a side in Inches; Get the Perpendicular from the Center to a side also in Inches: So shall the mean Proportional between the Perpendicular and half the sum of the sides be the side of a Square equal to the Base: which having found; Measure it as square Timber.

Examp. A piece of Timber of eight sides is 10 f. long: The side 12 inches: the Perpendicular 14,48 in. which you may call 14½. Set 14½ to 14½; against 48, half the Sum of the sides on the Line of Numbers, is 26.4 on the Sq. line; or there make a mark. Then set 12 to 10; against this mark is 48 f. and a little more than a quarter.

And thus much of these ways of Timber-measure, which, being the main occasion of the Rule, and not depending on any thing which followeth, I have set in the first place.

PROP. IX.

Having the Girt; To find the Side of the Square equal near.

This and the three following Propositions are wrought on the Double Scale: Yet I have here adjoyned them for their affinity with Timber-measure. And the proportional Numbers given in them are ready cut on the Rule, and give Contents to an exactness sufficient in any concerns of Timber.

As 7. to 7.9; So the Girt to the side of the Square equal. Let the Girt be 15 inches: On the Double Scale: Set 7. to 7.9; against 15 is 16.9 near. If you set 12 to the length in feet; this side shall point out a true Cylindrical Content.

PROP.

PROP. X.

Having the Girt; To find the side of the Square within near.

As 10 to 9; so the Girt to the side of the Square within near. *Examp.* Set 10 to 9; against 15 is $13\frac{1}{2}$. And so much will such a piece bear square.

By which you may know, before a piece be hewn, how many whole Board or Plank, of any thickness may be had out of it.

From hence also you may see, That the Girt, though less than the side of the Square equal; yet is greater than the side of the Square within: Toward which most Timber is hewn, before it can serve to any square uses. Which may be one reason of the continuance of the said common way: Of which opinion I find also Mr. *Henry Philips* to be, in a Treatise on this Subject.

PROP. XI.

Having the Diameter; To find the Side of the Square within near.

As 1 to .707; or to excuse a cut there, As 8.5 to 6; (being points equivalent near) So the Diameter to the side of the Square within near.

Let the Diameter be 19.1 *viz.* the Diameter of 60 inches Circumference. Set 8.5 to 6; against 19.1 is 13.5 near.

PROP. XII.

To find how many Inches in length make a Foot Solid, at any Girt or side of Square not exceeding 40 Inches.

Set the Girt or side of the Square on the Square-line to 1 at the beginning of the Line of Numbers; against 41.57 are the Inches which make a Foot.

So if you set 6 for Example to 1; against 41.57 is 48: and so many Inches in length make a Foot at 6 Inches Girt or side of Square.

And now having done with the Measure of ordinary Timber; Let me advertise any Reader that hath not seen much measured: That sometime he will find a great difference in the Girt of a Tree in the space of a Foot, more or less; for the most part, where one or more Arms have been cut off: In such case it is necessary to Girt the Tree twice, yea thrice, if there be cause: otherwise there will be loss to Buyer or Seller.

Also they say, The Buyer hath Privilege to Girt any where, between the middle and the ground end, if it be for his advantage.

PROP. XIII.

True Measure of a Solid, that tapereth strait.

Measure the length in feet: Note also the third part, which you may find by setting 3 on the Double Scale to the length; against 1 is the third part. If the Solid be round; measure the Diameters at each end in inches. Subtract the less Diam. out of the greater; half the difference add to the less Diam.; the Sum is the Diam. in the middle of the piece.

1. Set 13.54 to the length; against the Diam. in the middle is a fourth Number.

2. Set 13.54 to the third part of the length; against half the difference is a fourth Number. Both these fourth Numbers added together make the Content.

Examp. Let the length be 18 f. The third part is 6. Let the greater Diam. be 24. The less 16. The difference is 8. Half the difference 4 added to the less Diam. 16; The Sum 20 is the Diam. in the middle.

Set 13.54 to 18; against 20 is 39.27.	39.27
Set 13.54 to 6; against 4 is .524 which	.524
added to 39.27 maketh 39.794 or 39. f. and above three quarters.	39.794

Note, That 13.54 must be set to 6 in the second length, as in the second Case of round-Timber-measure the common way.

If the ſolid be ſquare; uſe the ſides of the ſquares at each end, in every reſpect as the Diameters, meaſuring them in Inches, *&c.* But let 12 be your firſt Number.

If it be any other regular figure; uſe the ſides of the Squares equal to each Baſe (found as is before ſhewn) as the other: Taking alſo 12 for your firſt Number.

PROP. XIV.

The Meaſure of a Shell or Flitch of Timber.

If a piece be taken out of the middle of a round piece of Timber from end to end; there will be left two pieces, which they call Shells or Flitches.

To find a near Content of theſe after the common way, with little trouble: Meaſure the length in feet: The round part, and the thicknes in the middle (taken with a pair of Calepers) in inches.

Theſe two with a third part of the thickneſs add together: a fourth part whereof account your girt, and meaſure as round Timber the common way.

If, on the double Scale, you ſet 3 to 4; againſt the thickneſs is it ſelf with a third part added to it.

Examp. Let the length be 30 f. The round part 25.3 in. the thickneſs 7.2 in. Set 3 to 4; againſt 7.2 is 9.6. which added to 25.3, maketh 34 9 The fourth part whereof is 8.7 near.

Or prick the ſaid 9.6 on the flat part in the middle from one ſide; and keeping the end of your Line at the other; Girt the whole round part, and to the ſaid prick: Double the line twice, and meaſure it in inches for your Girt.

Set 12 to 30; againſt 8.7 is 15 foot and three quarters.

Note, That this holds not ſo well in Sections cut far from the middle of the piece: In others, It giveth a content ſomewhat leſs than the common way: which may the better be born with, becauſe there is

more loss in these than in other pieces. And as they fall short of the middle pieces in value, so a less exact measure may serve.

PROP. XV.

Having the Diameter; To find the Area or Superficial Content of the Circle.

Set 1 on the Sq. line to .7854: Or to excuse a cut there; Set 11 to 9.5; against the Diam. is the superficial Content.

Examp. Let the Diam. be 1.7 f. Set 11 to 9.5; against 1.7 is 2.27 f. near.

By the Logs. to the Log. of the Diam. twice, Add this Log. 9.89509 being the Log. of the Decimal .7854; The sum is the Log of the superficial Content.	1.7	{0.23045 {0.23045	
	.7854		9.89509
	2.27		0.35599

Note, That if the Diam. exceed not 3.57; 1 in the middle is but 1: but if it exceeds 3.57; 1 in the middle is 100.

Here you may have occasion to make use of the Direction given in *Sect.* 5. *Part.* I.

Hence it is as easie, having the superficial Content to find the Diam. or to cast any Number into a Circle. So may the Gauge-points be put on; For they being the Diameters of Circles, whose Area's are equal to the Number of Cubick inches in the Galon of Wine or Ale respectively: If you set the Rule as above; you will see the Wine-point stand against 231: and the Ale-point against 282.

PROP. XVI.

Cask-Gauging.

The figures of these Vessels being uncertain, The staves of some being more Circular from head to bung, and so more capacious than other; The late Gaugers distinguish them into four kinds: The Sphæroid, whose

whose staves are most arching, and this contains most: The Conick whose staves from head to bung are strait (if any such can be made), and this contains least: The Parabola whose staves are arching, but neater to the Sphæroid than to the Conick: The Conoid, whose staves are arching, but nearer to the Conick than to the Sphæroid. All these may have the same dimensions of length and Diameters; yet differ considerably in the Contents.

Mr. *Everard* in his absolute piece, *Stereometry made Easie*, Printed 1684. giveth a Diagram of all the Kinds, and Rules for each, both by Arithmetick and the sliding Rule, except for the Conick: There being (as he saith) none such made; yet the figure thereof is useful to the distinguishing the other.

Mr. *Wingate* took no notice of these several kinds. His general way applied to this Rule is thus.

Measure the length of the Vessel within, the Diam. at the Bung, and the Diam. at the Head in inches and tenths. Subtract the Diam. of the Head out of that at the Bung. The difference multiply by 7; and divide the Product by 10. on the Rule easily thus: On the double Scale: set 10 to the difference; against 7 is the Quotient, which is 7 tenths of the difference.

These added to the less Diam. The sum is an æquated Diam.

Then set the Gauge-point, whether of Wine or Ale, to the Length; against the æquated Diam. is the content in Galons.

Mr. *Everard* agreeth with Mr. *Wingate* upon 7 tenths near for ten inches difference of Diameters, and accounts them to the Sphæroid: in other differences of Diameters, they differ more.

His Numbers for ten inches difference are; for the Sphæroid 7.01; for the Parabola 6.39: for the Conoid 5.62.

In other differences, The Rule differs something from his Table, to which I refer you:

To find the Content of a Cask in all these kinds. Let the length be 34.5 : The Diam. at the Bung 29.4 : That at the Head 25.3 : This deducted out of that at the Bung ; The Remainer or difference is 4.1.

Set 10 to 4.1 ; against 7. is 2.87 for the Sphæroid: against 6.39 or 6.4 is 2.62 for the Parabola : against 5.62 is 2.3 for the Conoid.

These added severally to 25.3 ; The sum is 28.17 for the Sphæroid : 27.92 for the Parabola : 27.6 for the Conoid, for æquated Diameters.

Example. Set the Ale-point to 34.5 ; against 28.17 is 76.25 Gal. for the first : against 27.92 is 74.9 Gal. for the second : against 27.6 is 73.2 Gal. for the third : such is the difference (upon account of their shape) by these Numbers.

By the Logs. To this general Log. 7.53148, for Wine : To this 7.44484, for Ale : Add the Log. of the length, and the Log. of the æquated Diam. twice ; the sum is the Log. of the Content : as you see here for Wine.	*Gen. Log.*		7.53148
	34.5		1.53782
	28.17	1.44979	
		1.44979	
	93.08		1.96888

The Fractions are thus reduced to pints : On the double Scale set 10 to 8 ; against the Decimal are the pints answering.

The Sphæroid may be known by the round swelling of the staves from one Head to another. If you lay a strait Rule on the Hoops of a Cask from the Head toward the Bung : and it toucheth, or very near, the Hoop next the Head and that next the Bung ; you may account it a Conoid. If the Rule librate upon the middle Hoops, like the beam of a ballance, and yet the staves not much swelling ; account it a Parabola.

Besides the shape of these Vessels, I have observed two things not noted by any to my knowledge, which may render the Gauging them uncertain. One is the joyning staves of unequal thickness, not taking care to smooth

ſmooth them within, which may cauſe an Errour of ſome tenths in taking the Bung Diameter.

The other this. The Head Diam. may be taken too great, though taken without: by reaſon of the paring away and ſmoothing the inward ſide of the Cask at each end, in order to the putting in the Heads. So that in reaſon it ſhould exceed the Diam. pointed out by the ſtaves, which is the true Diam. Both theſe I have ſeen in Cask, that have been cut aſunder.

PROP. XVII.

Gauging and Inching of Tuns.

Theſe are of ſeveral figures, but moſt are ſquare or round.

The ſquare are either equal ſided or unequal: both right angled, and may be conſidered as the ſame.

The round are either Cylindrical: *viz.* having the Diameters at top and bottom equal, (if any ſuch can be Hoopt) or Conical, whoſe Diameters at the top and bottom are unequal.

Alſo the Content may be required: either Total; or only of ſome Liquor contained in them.

The Content is ordinarily found firſt in Ale-gallons: which are reduced to Beer-Barrels by dividing the Number of Gallons by 36: or to Ale-Barrels by dividing the ſame by 32. Alſo a Barrel containeth 4 Firkins: So 9 Gallons of Beer: 8 Gallons of Ale make a Firkin. The Dimenſions, *viz.* Lengths, Breadths, Depths and Diameters are taken in Inches.

SECT. 1.

Square Tuns.

On the double Scale ſet 282 (cut on theſe Rules) to either length or breadth; againſt the other is the Content in Gallons at 1 inch deep, which being reduced to Firkins and Barrels, as it will bear: By a continual

tinual addition, as we add pounds, ſhillings and pence; a Table may be made to any Number of inches deep.

Or if you ſet 1 on the ſaid Scale to any depth in inches or this content; againſt the other is the Total content. Or multiply them by the Pen.

Examp. The length is 84 inches: the breadth 62 in. Set 282 to 62; againſt 84 in the firſt length is 18.47 Gal. Or 2 Firkins, 2 Galons, and near an half of Ale: which you may add, as in the Margin.

In.	*B.*	*F.*	*G.*	*Pts.*
1	0	2	2	47
2	1	0	4	94
3	1	2	7	41
4	2	1	1	88
5	2	3	4	35
6	3	1	6	82
7	4	0	1	29

Let the depth be 26 in. Set 1 to 18.47: againſt 26 is 480.22, which is near a quarter.

By the Logs. To this Gen. Log. 7.54975 add the Logs. of the length and breadth; The Sum is the Log. of the Content at 1 inch deep. And if to this you add the Log. of the depth; The Sum is the Log. of the whole content. Or if to the ſaid Gen. Log. you add the Logs. of the length bredth and depth; The ſum is the Log. of the whole Content, without notice taken of the Content at 1 inch deep.

Gen. Log.	7.54975
84.	1.92428
62.	1.79239
18.47	1.26642
26.	1.41497
480.2	2.68139

Becauſe it is likely there will be Tenths of an inch wet: On the double Scale ſet 10 to the Content in gal. at 1 inch deep; againſt every tenth is his own ſhare or part of the ſaid galons. Let the tenths be 6: Set 10 to 18.47; againſt 6 is 11 gal. belonging to 6 tenths. They put no pints into the Table.

SECT.

SECT. 2.

Cylindrical Tuns.

Having the Diam. of a Cylindrical Tun in Inches; To find the Content in Ale-Galons at 1 Inch deep.

If the Diam. exceed not 40 inches: Set the Ale-point to 1 in the middle; againſt the Diam. is the Content, 1 in the middle being one gallon.

If the Diam. be above 40 inches: Set the ſaid point to 10 at the end; againſt the Diam. is the Content, 1 in the middle being 10 gallons.

Which Contents, being for 1 inch deep, may be firſt reduced, and then added continually for a Table: or, before it be reduced, multiplied by the depth for a Total Content.

Or ſet the Ale-point to the depth; againſt the Diam. is the Total Content.

Examp. Let the Diam. be 58 in. Set the Ale-point to 10 at the end; againſt 58 is 9.37 gallons, the Content at 1 inch deep: Let the depth be 36 in. Set the ſaid point to 36; againſt 58 is 337.3 gal. Or multiply the depth and Content at 1 inch deep, by the Rule or Pen.

By the Logs. To the gen. Log. for Ale, add the Log. of the Diam. twice; The Sum is the Log. of the Content at 1 inch deep.

And if you uſe the Log. of the depth as in the former Section, you will have the whole Content.

	Gen. Log.	7.44484
58.		1.76343
		1.76343
9.37		0.97170
36.		0.55630
337.3		1.52800

SECT. 31

Conical Tuns.

1. To find the whole Content; Proceed as in the Measure of a Solid that tapereth strait *Prop.* 13: only measure the depth also in inches: and instead of the point at 13.54, use the Ale-point, as also the gen. Log. used in the Section next above, which belongeth to it.

2. But in order to inching them; In small ones and Keelers, they use only the Diam. in the middle and account them as Cylinders. But in the larger, they take one in the middle of every Ten inches (beginning at the bottom) as also in the middle of the remaining inches, except they be few, for then they account them to the last Ten, and take the Diam. in the middle. These Tens also they account as Cylinders.

3. Having found the Content answering the Diam. next the bottom, as is shewn *Sect.* 2; Put it into Firkins and Barrels as it will bear, and by a continual addition (as in *Sect.* 1.) make up the said Ten inches.

Then add the Content, answering the next Diameter, so reduced; inch by inch to the last Sum: and so proceed, till you have finished.

4. In a regular Tun: Having the Diameters at top and bottom, and the perpendicular depth; you may find any intermediate Diam. thus:

Divide the difference of Diameters by the depth; The Quotient multiply by any distance from the greater Diam. and subtract the Product from the said Diam.; The Remainer is the Diam. at that distance. Or multiply the Quotient by any distance from the less Diam. and add the Product to the said Diam, the Sum is the Diam. at that distance.

5. If the Tun be not exactly round: Measure two Diameters, where you observe the inequality; Add them together, and take the half: Let the said two Diameters be the longest and shortest: which will cross one another near at right Angles.

6. Be-

6. Becauſe moſt large Tuns are Fixed, and that dripping; for the better deſcent of the Liquor: The Square ones for the moſt part corner-wiſe; and the crowns or bottoms of the round ones commonly uneven and irregular; I adviſe you to fill up the ſaid crowns or bottoms, as alſo the crowns of Coppers, by Meaſure till they be wholly covered.

Which may be done by a Veſſel of known quantity, or you may Gauge one or a Pail: or by a true Galon: (for making which Directions are after given, which may alſo be otherwiſe ſerviceable) or in large Tuns beſt of all by both Veſſel or Pail, and Gallon; uſing the Veſſel firſt, and, when near covered, the Galon.

7. When the Bottom is covered, aſſign the Gauging-place, (where the water covers a whole inch, if it may be: if not, make it up by meaſure) and fix it by a mark: And note the wet inches. Mark alſo the ends of the Diameters at the Superficies of the water: as alſo the Perpendicular or neareſt diſtance of the top of the Staff from the water where the diſtance is leaſt, and the length of the Staff from the water in the ſame place. Of all which having taken an exact account; Let out the water, and from the aforeſaid marks begin the meaſure of your ſeveral ten or twelve inches, and to the quantity before meaſured in; Add your Contents inch by inch. The Content will be exact enough if you take a Diam. in the middle of every twelve inches.

8. Theſe ſeveral ten or twelve inches, being underſtood to be of the Perpendicular depth: To avoid an Errour, which in ſome Caſes may be conſiderable: On the double Scale ſet the Perpendicular depth to the length of the Staff; againſt any Number of the ſaid depth is the Number anſwering on the Staff, which is always greater than that of the depth.

9. The proportional parts of any Content belonging to any Diam. found as before, are to be ſet down, every part againſt his own Tenth, in a Column by themſelves

ſelves againſt the Contents of the whole inches: To be uſed for the parts, which for the moſt part happen to be over and above the whole inches.

10. Reduce not the Decimals of a Gallon; (The addition of them being eaſie, and becauſe they make not their Table to Pints) except perhaps in the proportional Gallons.

11. The Diameters, whether long or ſhort, are meaſured by ſliding Rules numbred in inches, as they are drawn out; (or in Gallons, which will ſave you ſome trouble) and are made to ſet together (ſo as to be portable) to a great length.

What hath been ſaid of theſe Tuns may be underſtood of Coppers, Coolers, or any other Veſſels uſed for Wort, either round or ſquare.

12. In an Oval Tun: Find a mean Proportional between the longer and ſhorter Diam.; It is the Diam. of a Circle equal to the Oval.

13. As for a true Gallon; To any Diam. in inches, which you chuſe, find the Content in inches, (as *Prop.* 15.) By which divide 231 or 282 for Wine or Ale reſpectively: The Quotient found to the hundredth part of an inch is the depth. *Examp.* The Diam. is 6 in.

The ſuperficial Content anſwering is 28.27. By which, dividing 231 the Quotient is 8.17 the depth of the Wine Gallon. By which again, dividing 282 the Quotient 159.97 is the depth of the Ale Gallon.

If you would have it ſquare; Divide the ſaid two Numbers by the Square of the ſide in inches. Let the ſide be 5 inches. By 25 divide 231 the Quotient 9.24 is the depth of the Wine Gallon. And again, By 25 divide 282 the Quotient 11.28 is the depth of the Ale Gallon.

PROP.

PROP. XVIII.

To Gauge a Stand.

It may be accounted a close Conical Tun: and measured as a solid that tapereth strait, *Prop.* 13. Only (as in the Conical Tun) measure the depth also in inches: and instead of the point 13.54, use the Gauge-points, and the gen. Log. belonging to them. As in this Example in Ale.

Let the depth be 33 in. a third part thereof is 11. Let the greater Diam. be 30 in: The less 24 in. The difference is 6: The half-difference 3; which added to the less Diameter, the Sum 27 is the Diam. in the middle.

1. Set the Ale-point to 33; against 27 is 67 Gal.
2. Set the said point to 11; against 3 is .27 or about a quarter of a Gallon. So the Content of the Stand is 67.27 Gal.

So little is the difference between the exact Content, and that found by the Diam. in the middle.

PROP. XIX.

To enlarge or diminish a Circle, Square, or other Regular Figure at a Rate given.

The proportion (respecting the Rule) is: As one term of the rate, to the Square of the Diameter or side given; So the other term to the Square of the Diameter or side required: Therefore the root thereof is the Diam. or side demanded.

Also if you would enlarge; the less term of the Rate is first: if you would diminish, the greater is first.

Examp. 1. If 1000 Men lodge in a Square whose side is 60 paces; How many paces shall the side of a Square be wherein 5000 Men may so lodge?

Here the second Number being on the first or moveable Rule; it is most convenient to set 60 on the Sq.

line to 1000 in the middle of the Line of Numbers; againſt 5000 on the Line of Numbers is about 134, and ſo many paces muſt the ſide be.

Ex. 2. I would diminiſh a Circle, whoſe Diam. is 10 f. at the rate of 8 to 5: Set 10 on the Sq. line to 8 on the Line of Numbers; againſt 5 on the Line of Numbers is 7. 9 f. the Diam. required.

PROP. XX.

Having the Dimenſions of the parts of a Ship, which make the faſhion or ſhape; together with the Burthen thereof: To find the Dimenſions of the ſaid parts for a Ship of any other Burthen greater or leſs, Retaining the faſhion or ſhape of the given Ship.

This Propoſition I find in Mr. *Norwood*; but wrought with great trouble. Since the invention of the Logarithms by the Lord *Nepair*, (whoſe Name will never be forgotten) it is performed with great eaſe: either by the Line of Numbers, with a Cube-line, being a Line of a Triple Radius, adjoyned: or moſt exactly by the Logs. For want of the aforeſaid Cube-line, Take this way by Compaſſes on the Line of Numbers.

Divide the ſpace between the burthen given, and that required into three equal parts. With this extent, Set one foot of the Compaſſes on each of the ſaid Dimenſions.

If the burthen required be greater than the given; Turn the other foot forward to a greater Number: If leſs; turn it backward to a leſs Number: which ſhall be the Dimenſions required. *Example.* in Feet and Tenths.

The

The burthen given	100 Tun.	Required 280 Tun.
	f.	*f.*
Length of the Keel	50.5	71.2
Length of the Midſhip-beam	21.	29.6
Depth of the Hold	9.	12.7
Raking forw. of the Stem	13.5	19.
Raking backw of the Stern	4.	5.6

By the Logs. Subtract the Log. of the leſs Burthen from the Log. of the greater: The difference divide by 3. The Quotient or third part add to or ſubtract from the Logs. of the ſeveral Dimenſions of the given Ship: according as the Burthen required is, greater or leſs than the given; The Sums or Remainers ſhall be the Logs. of the Dimenſions for the Burthen required.

This, holding in the Dimenſions of Maſts, Yards, Cables, Anchors, *&c.* muſt needs be of great uſe, being ſo eaſily wrought: eſpecially to the Ship-wright; it freeing him from groſs errour; and by it he may be inſtructed to provide and order his Materials to the beſt advantage.

The Art of Practical Measuring *easily Performed*, &c.

Part IV.

The Use of the double Scale of Numbers in some Superficial Measures and Accounts.

Directions.

1. IN the Rule of Three direct. If the second Number be greater than the first; the fourth shall be greater than the third; and on the contrary.

But in the Inverse Rule: If the second be greater than the first; the fourth shall be less than the third; and on the contrary.

2. If, setting the first to the second, the third reacheth beyond the Line; either remove the first to the second in the other length of the second Line: or take the third Number in the other length of the first Line.

3. The second and third Numbers are never taken both on the same Line.

4. Observe well what Number goeth with the Question: for in the direct Rule, That, of the other two, which agreeth with it in name or respect, is the first: which you may set to either of the other.

As

As if the Queſtion be: If 32 Bricks pave one ſquare yard; how many bricks will pave 12 yards? Here 12 is the third Number: and 1 the firſt; (both being of a name) which ſet to 12 or 32; againſt the other is 384 Bricks. But for the moſt part the firſt Numbers are given, as you will find after.

5. It is not hard to know the value of the fourth Number: for every Number on the Line increaſing or decreaſing in a Ten-fold Proportion; the nature of the Queſtion, or the thing meaſured will diſcover it. As in the Example above, the fourth Number may be 384, or 38.4, or 3.84. But it is evident, that it cannot be either of the two latter, much leſs 3840; So is it in any other.

PROP. I.

Multiplication; 1 being the firſt Number.

Sect. 1. *The Square.*

Multiply the ſide by it ſelf. Let the ſide be 14 f. Set 1 to 14; (beſt in the firſt length) againſt 14 on the firſt is 196 f. This is alſo found on the Sq. line.

Sect. 2. *The long Square.*

Qu. 1. Multiply the longer ſide by the ſhorter. A Wall is $30\frac{1}{2}$ f. long 1 and 16 f. high. Set 1 to 16; againſt $30\frac{1}{2}$ is 488 f.

Qu. 2. A length is 42 f. the breadth $0\frac{3}{4}$ f. Set 1 to 42; againſt the Decimal .75 is $31\frac{1}{2}$ f.

Q. 3. How many Men are in a Body, where they ſtand 18 in front and 8 deep. Set 1 to 8; againſt 18 is 144.

Sect. 3. *The Triangle.*

Multiply the Baſe and Perpendicular, the one whole by half the other, which you will. In the Pike-end of an Houſe: The overway is 18 f. The diſtance from the Pike to the overway (being the Perpendicular) 16

Set 1 to 8; againſt 18 (as before) is 144 f. Or, Set 2 to either Perpendicular or Baſe; againſt the other is the Content.

Sect. 4. *The Trapezium.*

It is an irregular four-ſided Figure. An irregular Plot (as of Land) before the Content can be found, is divided into theſe Trapezia, and Triangles.

To find the Content, draw a Line from one corner to his oppoſite one through the Trapezium: So as (if it may be) the two Perpendiculars falling from the other two Angles upon this Diagonal Line, (as they call it) may fall within the Trapezium: yet if one falls without, the Rule holds; but then the ſaid Diagonal Line muſt be produced far enough.

So have you two Triangles having one common Baſe. Multiply this Baſe by half the Sum of the Perpendiculars; the Product is the Content of the Trapezium. Or ſet 2 to the Baſe; againſt the Sum of the Perpendiculars is the Content.

There is a Trapezium much uſed by the beſt Surveyors of Land: Who, when they meaſure againſt a crooked limit, (be it Hedge, Ditch or River) carry their Chain ſtrait from mark to mark; and taking Perpendiculars from the Chain to the bents, nooks or windings of the limit, deſcribe Trapezia's in their Plot, have each two parallel ſides, and two right Angles.

The Content is found, by multiplying half the ſum of the parallel ſides (being the perpendiculars), by the neareſt diſtance between them, being the intercepted part of the ſaid Chain-line; The Product is the Content.

So is meaſured any Trapezium, which hath two parallel ſides, though the Angles be not right: But then one ſide muſt be continued, if need be: for this Line of neareſt diſtance muſt be perpendicular to the parallel ſides.

Thus

Thus may the Rhombus and Rhombold be measured, and infinite others neither æquilateral nor æquangular.

Sect. 5. *Any Regular Figure.*

Whose sides being equal, the Angles are also equal. Multiply half the sum of the sides by the perpendicular let fall from the Center to one of the sides.

Example. A Table hath 6 sides: each side 2 f. the perpendicular 1.73 f. Set 1 to 1.73; against 6 is 10.4 f.

Sect. 6. *The Circle, and his Parts.*

1. The Superficial Content hereof is best found by *Prop.* 15. *Part* III. It is also found by multiplying half the Circumference by the Semi-diameter.

2. For the Semi-circle. Multiply half the Arch-line by the Semi-diameter.

3. The Sector, which is any part contained between two Semi-diameters and the Arch-line, is also measured the same way.

4. If a strait line be drawn through a Circle, not through the Center; it divides the Circle into two Segments. The measure of the less is thus. Measure the Sector, whereof the Segment is a part; then subtract the Content of the Triangular part: The remainer is the Content of the Segment. But in the greater Segment; the Content of the included Triangle must be added.

5. Having the Chord (*viz.* the strait line abovementioned) of a Segment, and the part of the Diam. intercepted between the Chord and the Arch; to find the whole Diameter.

As the intercepted part of the Diam to half the Chord; So the said half Chord to the other part of the Diam. Add them and you have the whole.

6. The Diameter and Circumference are as 7 and 22. Set 7 to 22; against any Diam. is his Circumference. Set 22 to 7; against any Circumference is his Diameter.

Or

Or having ſet 7 to 22; againſt the Circumf. on the ſecond is the Diam. on the firſt.

Sect. 7. *To reduce the aforeſaid figures to Squares.*

Some of them, as the Triangle, long Square, *&c.* are reduced; as is ſhewn in the meaſure of Timber of ſuch Baſes: The other, as alſo any irregular Figure thus: Firſt, find the ſuperficial Content: Then ſet the Sq. line to his ſquares, as is before taught, againſt the ſuperficial Content on the Line of Numbers is the ſide of the ſquare.

PROP. II.

Diviſion, wherein the Diviſor is the firſt Number.

Qu. 1. If 32 Bricks pave 1 ſq. yard; how many yards will 500 Bricks pave? ſet 32 to 500, or to 1; againſt the other is 15.6 yards.

Qu. 2. If 25 Trees coſt 21 *l*; what doth 1 Tree coſt? Set 25 to 21 being neareſt; againſt 1 is 0.84 *l.* whereof the 8 is 16 ſhillings, and the 4 is 9 *d* $\frac{1}{2}$, as you will after ſee.

Qu. 3. The Content of a Rectangle or long Square, being divided by one ſide; (whether the longer or ſhorter) The Quotient is the other. Suppoſe 144 Men placed 24 in Front; How many deep do they ſtand? Set 24 to 144; againſt 1 is 6.

PROP. III.

The Rule of Three Direct.

Sect. 1.

When the length is meaſured in feet; the breadth in inches, and yet the content required in feet; 12 is the firſt Number: marked as 12 on the Sq. line, chiefly for the meaſure of Plank, or Board and Glaſs.

Qu. 1.

Qu. 1. A Plank is 36 ½ f. long, 18 inches broad: Set 12 to either length or breadth, here to 18, being neareſt; againſt 36 ½ is 54 ½ f.

Qu. 2. A Board is 14 f. long: 26 in. broad: ſet 12 to 14; againſt 26 is 30 ⅓ f.

Qu. 3. A Pane of Glaſs is 2 ¼ f. long: 7.6 in. broad: ſet 12 to 7.6; againſt 2 ¼ is 1.42 f: which .42 is almoſt an half.

Sect. 2. *Sawyers Meaſure.*

They account 120 to the hundred: If you would know the Content of a ſtock of Plank or Board in ſuch Meaſure: having found the Content of one Plank or Board by the *Section* aforegoing; ſet 120 (repreſented by 12) to the ſaid Content; or to the Number of Karfes or Cuts (which are always leſs by one, than the Number of whole Boards in the ſtock) againſt the other are the Sawyers hundreds: which will fall in the ſecond length, except there be not one hundred foot in the ſtock. The Tenths are each of them 12 foot.

Examp. Admit there were 22 Boards in the ſtock mentioned *Qu.* 2. of the aforegoing *Section*: the Content of one Board is 30 ⅓. Set 12 to 21 the Number of Karfes; againſt 30 ⅓ is 5,31 near:

Which is 5 hundred and 37 f. For every tenth being as is ſaid 12 foot: If you ſet 10 to 12; againſt 31 is 37 and more.

Sect. 3. *Glaſs.*

It is moſt convenient in Glaſs to meaſure the length as well as breadth in inches: yet the Content being required in feet; 144 (repreſented by 14.4) is your firſt Number: and the Content, if a whole foot or above, in the ſecond length, as next before.

Examp. A Pane of Glaſs is 31 ½ in. long: 8 ½ broad: ſet 144 to 8 ½; againſt 31 ½ is 1.86 f.

Let there be 7 ſuch Panes: ſet 1 to 1.86; againſt 7 is 13 f.

Sect. 4.

Sect. 4. *By the Yard.*

In the following Queſtions both length and breadth are to be meaſured in foot meaſure. If the Content be required in yards; 9 is the firſt Number: There being 9 ſq. feet in a ſq. yard. So they meaſure Painting, Paving, Plaiſtering, Wainſcot, *&c.*

Examp. A length is 24 f. the breadth 10 ½: ſet 9 to 10 ½; againſt 24 is 28 yards.

Sect. 5. *By the Square of* 10 *Foot. As in Tiling, Flooring*, &c.

Here 100 is the firſt Number. A Roof is 41 f. long: and the Sparr 20 ½ f. Set 100 to 41; againſt 20 ½ is 8.4 Squares.

Sect. 6. *By the Sq. Rod at* 16 ½ *f. to the Rod, as in Brick-Walls.*

Here 272 ¼ (being the ſquare of 16 ½) is the firſt Number: Alſo 272, being cut on theſe Rules, may ſerve without conſiderable errour. A Wall is 110 f. long: 9 ½ f. high: ſet 272 to 110; againſt 9 ½ is 3.83 Rod, in the ſecond length. If you would have a mark at 324 the ſquare of 18: ſet 18 to 10; againſt 18 on the ſecond mark the point.

Sect. 7. *By the Acre.*

In Land-meaſure 160 ſq. Perches, Poles, or Rod (commonly at 16 ½ f. in ſome places 18 f. to the Pole) make an Acre: Therefore 160 (repreſented by 16) is the firſt Number. The parts are 40 Pole to the Rood or quarter: 80 to 2 Roods: 120 to three. The lengths and breadths are meaſured in Poles.

Examp. 1. A length is 35 Perches: the breadth 19: ſet 160 to 19; againſt 35 is 4.15 Acres.

Examp. 2. A Triangular piece of Land hath the Baſe 24 Poles; the Perpendicular 16 ½: ſet 160 to 16 ½; againſt

againſt 12 (half the Baſe) is 1.24 Acre, near. Or ſet 320 to the Baſe 24; againſt the Perpend. 16 ½ is 1.24, as before.

PROP. IV.

The Inverſe Rule.

Here the Number that goeth with the queſtion is the firſt Number, which you may ſet to either of the other.

Examp. It ſeems 272 ¼ f. make a Rod of Brick wall only at 1 ½ Brick thickneſs. If it be thicker; fewer feet anſwer a Rod: If thinner; then more, at an Inverſe Proportion.

If it be demanded how many feet anſwer a Rod (for Example) at two brick thickneſs:

Set 2 (which goeth with the queſtion) to 1 ½; againſt 272 ¼ is about 204. *viz.* 204.18 f. And ſo for any other thickneſs: which may be marked for firſt Numbers thus: ſet 1 ½ to any thickneſs; againſt 272 ¼ on the ſecond mark the points.

PROP. V.

Fractions.

By Fractions I mean Decimals. A general Rule for them is: ſet 10, or 100 to the Number of parts (that make the whole) in the Queſtion; againſt every Decimal is its own ſhare or portion of the ſaid parts.

Sect. 1. *Of a Pound ſterling.*

The firſt figure after the prick in any Decimal of a pound, is ſo many two ſhillings: double it therefore; and you have the ſhillings anſwering: 5 in the next place is one ſhilling. Theſe being accounted: ſet 100 to 24; againſt the remaining Decimal are the pence. If there be not 5 in the ſecond place: Having ſet as above; againſt the other is the pence; the farthings being very eaſily eſtimated on the Rule.

Examp. Let .688 be the decimal: The 6 is 12 *s.* and 5, in the next 8, is 1 *s.* ſet 100 to 24; againſt 38 the remaining decimal is 9 *d.*: in all 13 *s.* 9 *d.* Or

Or without the Rule thus: Having taken out the ſhillings, as above; If the remaining Decimal exceed not 30, account them farthings, abating one. If it exceed 30; Take 25 out of it, which is 6 *d.* and the remainer account farthings, abating one.

Note, That the Decimal is ſuppoſed of three places at leaſt: If it be but of two; ſuppoſe a Cypher for the third: and if there be more, you may neglect them, with the Caution in the like caſe before given.

So taking 25 out of .38; (in the Example above) the remaining 13 account 12 farthings or 3 *d.* ſo the whole is 9 *d.*

Sect. 2. *Of a Rod.*

At 30 *s.* the Rod what are 28 cents: Set 100 to 30; againſt 28 is 8.4, *viz.* 8 *s.* and 4 tenths: ſet 10 to 12; againſt 4 is 4 *d.* $\frac{3}{4}$: in all 8 *s.* 4 *d.* 3 *f.*

Sect. 3. *Of an Acre.*

How many Perches are 15 cents of an Acre? Set 100 to 160; againſt 15 are 24 Perches. More Examples are needleſs.

Sect. 4. *Vulgar Fractions into known Parts.*

Set the Denominator, being the lower, to his Numerator; againſt the Number of known parts in the whole is the Number of parts required. Or ſet the Denominator to the Number of parts; againſt any Numerator is his portion of the ſaid parts.

How many farthings are $\frac{5}{7}$ of a ſhilling? Set 7 to 48; againſt 5 is 34 or 8 *d.* 2 *f.*

Sect. 5. *Vulgar Fractions into Decimals.*

Set the Denominator to his Numerator; againſt 100 is the Decimal required. What Decimal of a foot is $\frac{7}{12}$ or 7 inches: ſet 12 to 7; againſt 100 is .58 near enough, or .583.

The aforegoing Examples being well underſtood; It will not be difficult to apply the double Scale to any other ſubject.

The

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Part V.

SECT. I.

The Diagonal Scale. (Fig. III.)

IT consisteth of 21 Equidistant Parallel Lines thorough the length of the Scale: and of Transverse Parallels at a quarter of an inch distance one from the other: with 5 Diagonals thorough the uppermost Integer. In the Parallel of 10 there is a Cypher at every Transverse. This row of Cyphers divides the whole Scale, into two Scales having one Diagonal Integer over both.

It is fitted chiefly to *Gunter*'s Chain, which is accounted the best for Surveying of Land: and is of 16 Perches in the Inch.

If the place of Tens in the Links be 0, 2, 4, 6, or 8; (the last four whereof are set against their respective Diagonals) Use the first or left hand Scale. But if the place of Tens be 1, 3, 5, 7, or 9; use the second or right hand Scale. For that Diagonal, which is 10 (for Example) in the first, is 30 in the second; that which is 40 in the first, is 50 in the second, &c.

Examp. 1. Let 10 Chains and 46 Links be required from the Scale: ſet one foot of the Compaſſes on the long Parallel or Link-line repreſenting 6 in the tenth Chain-line or Tranſverſe, and firſt Scale: and extend the other to the Diagonal 40, in the ſaid Link-line of 6.

2. But to take off 10 Chains and 56 Links: ſet one foot on the Link-line of 6 in the ſaid tenth Chain-line, and ſecond Scale: and extend the other to the ſame Diagonal in the ſaid Link-line of 6; ſo have you the Lines required.

3. So having a Line on your Plot; to know how many Chains and Links it is: Take it with your Compaſſes, and carry it parallel to the Link-lines: one foot in one of the Chain-lines: and the other, thorough the Diagonal Integer, till it falls on one of the Diagonals: And according as it falls in the firſt or ſecond Scale; ſo account the Tens of your Links.

The Scale may be made to 20 in the Inch; (as it is commonly to 12, and ſet on the other ſide) which muſt needs exceed any Plain Scale of that dimenſion, for exactneſs.

Sect. 2. *Gunter's Chain.*

It is 4 perches long at 16 ½ f. to the perch: Theſe make 792 inches. It hath 100 links: So each link is 7.92 in.

Thoſe Chains Mr. *Warner* ſells, are diſtinguiſhed with pieces of Braſs at every tenth link; which pieces contain ſo many corners or points as they ſignifie tens of links from either end of the Chain. As thus: That Braſs at 10 links has one tippet or point; that at 20, has two; that at 30, 3; that at 40, 4; and the ſame again from the other end, but at 50 the middle, is a large round piece of Braſs, and at 25, from each end two Curtain-Rings together. By the help of theſe diſtinctions (which are plainer and far more viſible than the old way of Rings alone) you will ſpeedily find the number of links.

Although

Although the Chain be divided into 4 perches, by the two double Rings, and the large brass Circle in the middle: so that it may be applied to the Measure of any length by the Pole; yet in Measuring lengths in Surveying; we take notice only of Chains and Links: not concerning our selves with perches till we cast up the Content.

To multiply a length and breadth Measured with this Chain; Reduce them into Links: which is no more trouble than to set the Links at the right hand of the Chains; or if there be no Links, to put two Cyphers there: So 4 Chains and 32 Links, are 432 Links: and 7 Chains, are 700 Links.

Having multiplied a length by a breadth: The sixth figure of the Product to the left hand (if there be so many) is Acres compleat: The seventh, Tens of Acres.

Exmp. 1. If you multiply 5 Chains and 82 Links, by 3 Chains and 21 Links; The Product is 1.86822 whereof the 1 is one Acre.

Ex. 1.

	582
	321
	582
	1164
	1746
	1.86822

Also 13 Chains and 42 Links by 8 Chains and 70 Links: The Product is 11.67540, whereof the 11 is eleven Acres. The Decimals are reduced to Roods and Perches as followeth.

Ex. 2.

	13.42
	870
	93940
	10736
	11.67540

Sect. 3. *To reduce the Decimal Links of* Gunter's *Chain into Poles.*

An Acre is 160 square Perches, as hath been said, equal to 100,000 square Links of this Chain: which being divided by 160; The Quotient 625 is the sq. Links of one Perch or Pole. This, as it is the Decimal of an Acre, ought to be expressed thus .00625:

as also all other, *viz.* with 5 places: except it be even Tens: for a Cypher or Cyphers at the left hand are of no value, as hath been said.

The parts of an Acre are first 4 Roods: wherefore 4 is your first Multiplier. And there being 40 Pole in a Rood; 40 is your second.

Or if you multiply your Decimal by 160; The figures remaining to the left hand, after the Decimal be cut off, are Perches immediately.

But where the Content is not exacted to half a Pole; we usually take this shorter course without prefixing Cyphers.

It is evident, that if the places of the Decimal be but three, there cannot be two Poles. If they be four, multiply the first figure by 6: If five, multiply the two first places by 6: In both, set the Product one place back toward the right hand: Then add together the first or two first places (respectively) of the Decimal and Product so set: Adding also a Unit for every 6, that shall be in the figures of the next place; The Sum is the Number of Poles in the Decimal.

See here two Examples; one of four places, the other of five. Also you see how the Products are placed and added.

Ex. 1.	*Links*	8172
		48
	Poles	13
Ex. 2.	*Links*	21726
		126
	Poles	35

In the first there is once 6, in the second twice 6 in the figures of the next place: for which 1 in the first, and 2 in the second are added to the other. The two places to the right hand are neglected, as never amounting to the sixth part of a Pole.

The reason of this Operation, Mr. *Wingate* (in whose Arithmetick I first met with it, used also by Mr. *Atwell*, as you may see in his Book of Surveying Printed *Anno* 1662, which I value beyond most Books of that Subject Printed since) deeming it not very obvious

obvious, leaves to the ſearch of the curious. Take it here.

1. If 100 (which are ſo many thouſand Sq. Links being an Acre) require 60 to be added to it, to make it 160 Poles, being alſo an Acre; what ſhall any other Number of thouſands of ſq. Links require to be added to it, to turn it into Poles?

2. To multiply a Number by 6, and divide the Product by 10, gives the ſame Quotient, which you have by multiplying the ſame Number by 60, and dividing the Product by 100.

3. Setting the Product a place back to the right hand, both divides by 10, and ſeats it for Addition.

Sect. 4. *A Ready and Exact Way by the Rule.*

On the double Scale: ſet 100 to 16; againſt the Links are the Poles anſwering. Neglect the two laſt figures, as is ſaid.

If the Decimal be 60,000 or more: Take 5 out of the firſt figure, accounting for it 2 Roods: and find the Poles anſwering the Remainer: Let the Decimal be .82511: Deducting 5, The Remainer is .32511. Set 100 to 16; againſt .325 is 52: *viz.* 1 Rood and 12 Pole: So the Decimal is 3 *r.* 12 *p.*

Sect. 5. *Having the three ſides of a right Line Triangle; To find the Superficial Content.*

Add the three ſides together: from half the Sum, ſubtract each ſide ſeverally: So you have three Remains; Multiply theſe three Remains, and the half ſum continually; that is, The firſt Remain by the ſecond, that Product by the third: And this Product by the half ſum; The Square Root of this laſt Product is the Superficial Content.

Moſt eaſily, and ſpeedily by the Logs. thus: Add the Logs. of the three Remains, and the half ſum together;

together; Half the ſum is the Log. of the Superficial Content.

Exam. Let the ſides be 1050, 854, 774. The half ſum is 1339: The three Remains 289, 485, 565. The Content is 3 Acres, 1 Rood, and 1 Perch near. This is the moſt certain way of Meaſuring Land: where the Triangles can be meaſured in the Field. Which otherwiſe are firſt plotted, and then caſt up by the Baſe and Perpendicular as hath been ſhewn.

1339	3.12678
289	2.46094
485	2.68574
565	2.75205
a.	11.02547
3.25640	5.51273
150	*a. r. p.*
41	3. 1. 01 near.

DIRE-

DIRECTIONS IN DIALLING.

PART VI.

CAP. I.

The Use of a Diagonal Scale, *In laying down Angles, with the help of the Natural Sines, or for want of them the Artificial or Log-Sines, applied to the putting the Hour-Points on large Plains.*

THE most convenient Scale for this purpose is that of 100 parts in the Inch. If you suppose the spaces between the long Parallels divided each into Ten parts; They are Milleſms or Thouſand parts, which are the leaſt that can be taken off the Scale. They are commonly made a foot long, and have on them ten Inches beſides the Diagonal one, diſtinguiſhed.

Alſo

Alſo account the Radius or Sine of 90°.00'. to be 10.0000: So the firſt figure of all the Sines above that of 5°. 44'. will be an Integer. That, and all under it to the Sine of 0°. 34'. Decimals of the firſt Rate: That, and all the reſt, except the Sines of the three firſt Minutes, of the ſecond: and thoſe of the ſaid three, of the third.

The general Rule is,

As the Semi-radius, The Sine of 30°.00', 5.0000
To the Semi-diameter;
So the Natural Sine of the half Arch
To the Chord of the whole.

Multiply the Sine of the half Arch and the Semidiam. and prick off the Decimal in the Product: Then for the diviſion by 5.: Double the ſaid Product, and prick off one figure more to the Decimal; This is the Chord.

Examp. For the Chord of 40°.00' to a Semi-diam. of 12 Inches. The Sine of 20°. 00'. *viz.* 3.4202 multiplied by 12; the Product is 41.0424. This doubled and one place more prick'd off, is 8.20848, or 8. inches, and 208 parts, which may be taken off the Scale for the Chord aforeſaid: The two laſt figures may be neglected.

If your Semi-diam. be not limited, it is done with far leſs trouble. For if you take 5 for your Semi-diam. The Sine of the half Arch is the Chord. If that be too little: Multiply 5 by any Number: and by the ſame multiply the Sine of the half Arch; The Product is the Chord. *Examp.* For the Chord of the ſaid 40°.00'. to a Semi-diam. of 30 inches, that is ſix times five: Multiply the ſaid Sine of 20°. 00'. 3.4202 by 6: The Product 20.5212 is the Chord: The laſt figure may be neglected.

Note, That although you take only three places of Decimals from the Scale: yet in Multiplication for a larger Semi-diam. it is beſt to take four.

If the Minutes of the Arch, whose Chord you seek, be odd: Add half of the difference of the Sines of the two Minutes, between which the half Arch falls, to the Sine of the less Minute. The half difference you may find by view, without writing.

If you have not the natural Sines; you may find them by seeking the Log. Sines in the Table of Logs. of natural Numbers: the correspondent Number is the natural Sine, with this direction: If the Index of your Log. Sine be 9; the first figure is an Integer: If 8; then the Number is a Decimal of the first rate: If 7; then of the second, *&c.* which is easily remembred.

CAP. II.

Directions in the Use of the Tables of Logs. of Sines, Tangents, and Natural Numbers; in order to the putting on the Hour-lines, and setting up the Style in the most useful Plains.

The Log. of the Radius, *viz.* the Sine of 90°. or Tang. of 45°. is 10.00000. Therefore to add the Radius to a Log. Sine or Tang. (for only such are here meant, though called barely Sines or Tangents) is to make the Index of it Ten more than it is: To deduct or abate the Radius, is to make the Index Ten less than it is.

1. In the Canons or Rules following: If the first be the Radius: Add the Logs. of the second and third; the Sum, (a Radius deducted) or nearest to it, found in the Tables gives the Sine, Tang. or Number sought.

2. If the second or third be the Radius; add them together: out of the sum deduct the first; the Remain, or nearest to it gives the fourth. Or rather, Add the Ar. Compl. of the first to that of the other two which is not the Radius; the sum of both gives the fourth.

Note, That the Tang. Compl. or Cotang. is the Ar. Compl. of the Tangent, omitting the Radius; and is always.

always in the same rank with the Tang. in the other Column, or in the other Page, according as the Tables are ordered.

3. If none of the three be the Radius: Add the Ar. Compl. of the first to the other two; The sum of all three gives the fourth.

4. If there be many proportions to be wrought: and the first and second, or the first and third (which in this case account the second) hold always the same: If the first be the Radius: write the second in a piece of paper at the top near the edge: the figures equal to those of the Table you use: and holding it under the third Numbers in the Table, Add them in a Column in another paper.

5. If the second or third be the Radius: write the Ar. Compl. of the first, and use it in every respect as before.

6. If none of the three be the Radius: write the difference of the first and second so: and holding it to the other: Add, if the first were the less: But deduct, if the second were the less. Or if you had rather add, write the Ar. Compl. of the difference, and add it.

7. If the second and third hold the same: write the sum of them at the bottom of a piece of paper near the edge: and holding it over the first Numbers in the Table; Deduct the said first Numbers.

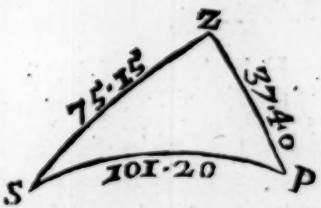
There are also proportions, where the Numbers are figurate: whereof here followeth an Example in finding the Hour and Azimuth.

But whereas in these there are sometimes Sides or Angles above 90°. So that the Complement to 180 must be used in their stead: I advise you (for saving that trouble) to write the degrees above 90 on the top of the Table, in the left hand column or page, near the printed degrees. As, near gr. 0, write 90: near gr. 1, write 91: near gr. 10, write 100: and so the rest in order, as far as you think you may have occasion: Always observing, that you use the Minutes under the said

said written Degrees: but the Sines themselves take in the other column or in the other page, being the Complements of these. So if you would use the Sine of 91°. 20′. in *Gellibrand's* Tables, seek the 20′. under gr. 1: But take the Sine against it in the right hand page, *viz.* 9.999 88, the Sine of 88°. 40′, as also of 91°. 20′.

CAP. III.

Having the Latitude of the Place, the Declination and Altitude of the Sun; to find the Hour and Azimuth.



IN the Triangle Z P S representing the Zenith or point over head, the Pole, and Sun. The side Z P is the Compl. of the Lat, Z S the Compl. of the Alt. S P the distance of the Sun from the Pole, which in the Summer half year is the Compl. of the Declination: but in the Winter half year is his Declination with 90 degrees added. Also the angle at P. is the hour, that at Z the Azimuth.

Let the sides be as in the Example, and the hour inquired. Add the sides: From half the sum take the side opposite to the inquired Angle, and note the difference.

To the Ar. Compl. of the Sines of the sides comprehending the inquired angle, Add the Sines of the half sum, and of the difference; Half the sum is the Co-sine or Sine Compl. of half the inquired angle.

	° ′
	101.20
	75.15
	37.40
S.	214.15
H.S.	107.07
	75.15
Dif.	31.52

The

The half sum of the Sines, *viz.*	.21391
9.96268 you will find to be the Sine	.00855
of 66°. 35′: whose Compl. 23°. 25′.	9.98032
doubled is 46°. 50′. This turned into	9.72259
time is 3 hours and 7 minutes from	19.92537
Noon; that is 7 min. before 9 or af-	9.96268
ter 3.	

Note, That 15 degrees make an hour, and 15 min. of a degree 1 min. of time.

For the Azimuth in this Example:	*H.*	107.07
the half sum is the same: but another		101,20
side being deducted; there is another	*D.*	5.47
difference.		

Half the sum of the Sines, *viz.* 9.60290	.21391
is the Sine of 20°. 37′. whose Compl. 66°.	.01455
23′. doubled is 132°. 46′: which is the Azi-	9.98032
muth from the North part of the Meri-	8.99703
dian. Out of which taking 90. The Re-	19.20581
main is 42°. 46′. and so many degrees the	9.60290
Sun was past the East point, or short of the	
West, at the time of that Observation.	

CHAP.

CAP. IV.

To find the Declination of a Plain.

1. IN order to which, Take this Table of the Refraction of the Sun in minutes, corrected by the Parallax, as far as 16°. alt. The uſe is, Take the minutes againſt the degrees, each out of his reſpective degree; So have you his Alt. free from Refraction. Alſo it is not uſual to make any Obſervation in this caſe after Ten, or before Two, of the Clock.

Alt. Degr.	*Refr.* Min.
0	31
1	23
2	17
3	14
4	12
5	11
6	10
7	9
8	8
9	7
10	7
11	6
12	6
13	5
14	5
15	4
16	4

2. Take a Board that hath a ſtrait ſide. On a center in a Diam. parallel to that ſide, and about half on inch or more from it, deſcribe a ſemi-circle. Divide it into two Quadrants: each Quadrant into 90: and ſubdivide it as you think fit; Number it with 10, 20, 30, *&c.* from each end of the Diam. to 90. Alſo it may be convenient to number the degrees on either ſide of 90, double: that is at 80, ſet 100: at 70, 110, *&c.* The part without the ſemi-circle may be cut off.

3. Apply the ſtrait ſide to the Plane, ſo as the ſuperficies thereof may be exactly Horizontal or level. Hang a thred with a Plummet ſo as it may caſt a ſhadow on the centre; when the ſhadow is on the centre, mark the degree cut by it in the ſemi-circle: At the ſame time let another take the Altitude of the Sun with a Quadrant or other Inſtrument.

4. Having found how many degrees the Sun is ſhort of or paſt the Eaſt or Weſt point: Set off that point which is on the Plain backward or forward reſpectively from the degree cut by the ſhadow, or point; The

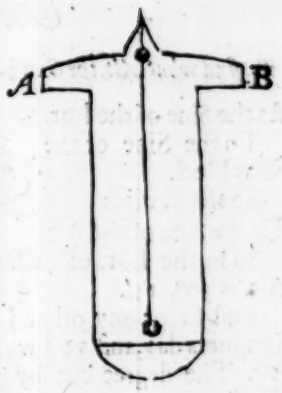
degrees intercepted between the Diam. and the ſaid point are the degrees of the Declination of the Plain: which is either East or West, according to the point that is on the Plain.

5. It may be convenient in ſome caſes to ſet off the South point from the degree cut by the ſhadow, by the Compl. of the Azimuth to 180: Then 90 degrees forward or backward will be the East or West point.

Note, That inſtead of the ſemicircle divided on the Board, it may be more convenient, (at leaſt for carriage) to have one ſo divided upon ſtiff paper, or paper-royal. For then, any Board, having a ſtrait ſide, and a Line drawn near and parallel to that ſide, being applied to the Wall as above; you may direct the ſhadow any where toward the middle of the ſaid ſtrait ſide. And at the time of obſervation of the Alt. of the Sun, make two pricks in the line of ſhadow, the one diſtant from the other as far as conveniently you can. Then taking the Board from the Wall, joyn the ſaid points in a line drawn at full length: and apply the Centre of your ſemi-circle, in the point of interſection of the line of ſhadow with the parallel line on the Board: and the Diam. exactly on the ſaid parallel line. So the line of ſhadow will ſhew the degree to be uſed in every reſpect as in *Paragr.* 4. of this Chapter. You may take two or more Obſervations; But then be careful to apply the Azimuth each time to his proper degree in the ſemi-circle.

Otherwiſe.

Upon a Board of about eight inches broad, exactly plained, Let a ſemi-circle of about ſeven inches ſemi-diameter be drawn and divided as above. Let a braſs Index about an inch broad be fitted to turn upon a pin in the Centre, having a point in the middle of the end, which may move round juſt by the Diviſions or amongſt them.



Let the end be as the Figure in the Margin: the distance from A to B two inches at the leaſt.

From the point let a Fiducial line be drawn thorough the Centre, and near the point in the ſaid line, let there be a hole for a ſmall thread or luteſtring, hollowed underneath for the knot of the ſaid ſtring.

Fix another Rule to this, of about ſix inches long, and the breadth of the other, at a right angle, a little behind the Centre, with ſcrews, as an ordinary ſight is fitted to the Index of a plain Table.

Placing it on the Centre, and the point at 90; Aſſign a point in the top, which muſt be equidiſtant from either end of the Diam. or from any two points therein equidiſtant from the Center. Through this point drill a hole, and through it draw a fiducial line down to meet the other line.

Let this Rule have a notch in the ſide near the bottom for a Plummet to be hung from the top, whereby the Board may be placed Horizontal.

Strain a ſtring through both the holes, and the Board being ſo placed, turn the Index to the Sun, till the ſhadow of the ſtring fall into the fiducial line of both Rules: and the degree pointed, note as before, &c.

CAP. V.

To find what Alt. the Sun hath when he is due East or West.

As the Sine of the Lat.		° ′	
To the Sine of the	*Sine of*	52.20 *Ar. Com.*	.10151
Suns Decl.	*Sine of*	23.30	9.60070
So the Radius	*Sine of*	30.15 *the Alt.*	9.70221
To the Sine of the Alt.			

So in the Lat. of 52°. 20′. and Decl. 23°. 30′. The Alt. is 30°. 15′.

And so for any other Lat. and Decl. If it be a fair Summers day, and you wait till the Sun cometh to that Alt. The degree cut by the shadow is the East or West point.

CAP. VI.

The Declination of the Sun.

THe Suns place in degrees and minutes for every day at Noon is in all Ephimerides, and in some Almanacks yearly: From whence his distance from the next Æquinoctial point being known; his Declination is found by this Canon:

As the Radius

To the Sine of the Suns greatest Decl. 23°. 30′;

So the Sine of his distance from the next Æquinoctial point.

To the Sine of his Declination.

But in case those should be wanting; I have subjoyned Tables of his Declin. for every day at Noon for four years together, with the years over them as they are in Sir *Jonas Moore's* new system of the Mathematicks: which will hold for some years forward. And for their further continuance I have adjoyned a Table of Seconds, taken out of Mr. *Wright's* Correction of Errours in Navigation, by the help of which they may be rectified, so as to serve for many years to come.

CAP.

CAP. VII.

To find the Aſcenſional Difference, or the time of the Suns Riſing or Setting from Six.

AS the Cotang. of the Lat.		*Cotang. of* 52.20	*Ar. Compl.* .11241
To the Tang. of the Suns Decl.		*Tang. of* 23.30	9.63830
So the Radius		*Sine of* 34.17	9.75071
To the Sine of the Aſcenſional Dif.			

So in the Lat. of 52°. 20′. and greateſt Declination, the Aſcentional difference is 34°. 17′. which in time is 2ʰ. 17ᵐ. wherefore the earlieſt Hour-line is that of a quarter before 4: and the lateſt a quarter after 8, which ought to be on the Dials of that Lat. Except they be made to half quarters or minutes, as ſome Horizontal Dials are.

CAP. VIII.

The Horizontal Dial.

AS the Radius
To the Sine of the Lat.
So the Tang. of the Hour in the Table following,
To the Tang. of the Arches of the Hour-line from the Meridian.

Write the Sine of the Latitude, as is before directed; and holding it under the Tangents of the hours, Add them in a Column againſt their own hours. Seek them or the neareſt among the Tangents; the Degrees and and Minutes anſwering are the ſaid Arches or Arks of the Plane: which ſet down in another Column, every one againſt his own Tang.

Draw a line on the Plain for the Meridian or hour of 12, and the Subſtylar. In it chooſe a Centre; out of which deſcribe an occult Circle, in which ſet off the ſaid Arks of the Plain from the Meridian on either ſide: which may be done by a line of Chords, or a

Protractor, (these Dials being for the most part small) or by a small Diagonal Scale as is before shewn. Lines drawn from the Center through these points shall be the hour-lines.

The hour-line of 6 crosseth the Meridian in the Centre at right angles. And the hour-lines before 6 in the Morning, and after 6 in the Evening may be supplied, by continuing their opposite hour-lines beyond the Center to the other side.

The Style must be put up in the Center over the Meridian at an angle equal to the Lat. of the place.

These are commonly made in Brass: and the style is a Brass plate: which being of a considerable thickness, The two edges cast the shadow, each on the hours next it. So the Dial is in two parts separated by a space equal to the thickness of the Style. But note that the shadow is cast upon the continued lines before and after 6, from the opposite edg of the Style, whereof care must be taken.

The Dials following are supposed to be made upon Board or Plank with Lead and Oyl, and to be fixed after they are made. The Style a round Iron rod, It

A TABLE

Of the equal Distances of the Hours in Degrees and Minutes: from 12, for the Horizontal and Vertical Dials: from 6, for the East and West Dials, being the Angles at the Pole.

12	0	6
.	3 . 45	.
X	7 . 30	X
.	11 . 15	.
11.1	15 . 0	7.5
.	18 . 45	.
X	22 . 30	X
.	26 . 15	.
10.2	30 . 0	8.4
.	33 . 45	.
X	37 . 30	X
.	41 . 15	.
9.3	45 . 0	9.3
.	48 . 45	.
X	52 . 30	X
.	56 . 15	.
8.4	60 . 0	10.2
.	63 . 45	.
X	67 . 30	X
.	71 . 15	.
7.5	75 . 0	11.1
.	78 45	.
X	82 . 30	X
.	86 . 15	.
6	90 . 0	12

It is beſt to Prime them on both ſides together, and to hang them ſo as a ſmall gale may turn the ſides ſucceſſively to the Sun: otherwiſe they may be drawn from the exactneſs, to which they ought to be made. Paint them thrice.

CAP. IX.

The East and Weſt Dial.

THere is no difference in the making of theſe two. The Hour-line of *6* is the Subſtylar: which muſt croſs the Æquinoctial-line of the Plain at right angles.

This Line muſt be drawn at full length: and the ſhape of the Dial ought to be an Oblong rather than a juſt Square.

The Hour-points may be prickt in the Æquinoctial Line from the Natural Tangents of the Hours in the Table, taken from a Diagonal Scale: on either ſide from *6*: *viz.* on the upper ſide according to the Aſcenſional difference: on the lower ſide to 11. or 1.: They are ſeldom put on further, for the great diſtance of the other quarters, and 12 cannot be put on.

If the Natural Tangents be wanting, they may be found in the Table of Log. Numbers, as is before directed for the Nat. Sines.

The Style muſt be Parallel to the Subſtyl. The height, in this caſe, as the Tang. of 45 *viz.* 10: which is alſo the diſtance of 9 and 3 from the Subſtyl. The Hour-lines are all Parallel to the hour of *6*, and ſo to one another; the Æquinoctial-line cutting them all in the middle.

This Line muſt be croſſed ſomewhere by an occult line at an angle equal to the Lat.: which in the fixing muſt be a Perpendicular or Plumb-line; (it pointing to the Zenith, from whence the Æquinoctial is diſtant according to that angle): by means whereof the Æquinoctial-line of the Plain will be adjuſted to the due height.

If the Plain be a fixed Plain, this Vertical, Perpendicular or Plumb-line must be first drawn by help of a Thread and Plummet: and then the Æquinoctial-line at the said angle, and then the Substyl. and the other Hour-lines as before.

But in large Plains, To proportion the distance of the Hour-lines, and the Style, to the Plain:

As the sum of the Nat. Tangents of 75°, and of the Ascensional difference,

To the length of the Æquinoct. line in Inches;
So the Nat. Tang. of the Ascen. difference

To the distance of the Hour-point of 6 from the upper end of the line.
And so is 10

To the height of the Style.

In the Lat. abovenamed: The Nat. Tang. of the Ascen. diff. is 6.817. That of 75°. 37.32. The sum 44.137. Let the Æquinoct. line of the Plain within the border be 32 inches: The distance of the Hour-point of 6 from the upper end of the said Line will be 4.94 inches: And the height of the Style and distance of the third hour 7.25 in. Then,

44.137	*Ar. Compl.*	8.35520
32.		1.50515
6.817		.83359
4.942		.69394
44.137	*Ar. Compl.*	8.35520
32.		1.50515
10.		1.
7.25		.86035

As the Tang. of 45°.

To the height of the Style;
So the Tang. of the Hours in the Table belonging to this Plain;

To their distance from the Substyl. Which gather into a Table as is directed in the Horizont. Dial.

The further Hours from the Substyl. ought to be longer than the nearer: Or the Style of a sufficient length: lest the shadow thereof at some time or other of the Day or Year goeth off the Plain. This Dial must be set in the Plain of the Meridian.

CAP.

CAP. X.

The Prime Vertical, or full South upright Plain.

PLacing the Dial, as it muſt be fixt, or if it be fixt; Draw a Vertical Line for the Meridian, or Hour of 12, and the Subſtylar. Toward the upper part chooſe a Centre, where croſs the ſaid Line at right angles with the Hour-line of 6.

As the Radius.
To the Coſine of the Lat.;
So the Tang. of the hour in the Table
To the Tang. of the Hour-line from the Meridian.

Which having gathered into a Table; out of the Centre deſcribe an occult Semicirle, and inſcribe theſe Arches (as you will be directed in the next) from the Meridian on either ſide.

The Style muſt be put up in the Center over the Merid. at an angl. equal to the Compl. of the Lat. for which you will have large and plain Directions afterward.

CAP. XI.

The Vertical Decliner, or the upright Declining Plain; The South face.

IN making this moſt uſeful Dial, after the Declination found,

1. We enquire the Inclination of the Merid. of the Plain to that of the place.

As the Sine of the Lat.
To the Radius;
So the Tang. of the Plains Declination
To the Tang. of the Inclination of the Meridians. Which aſſigns the place of the Subſtyl. among the Hours.

2. The height of the Pole above the Plain.

As

As the Radius
To the Cosine of the Lat.
So the Cosine of the Decl.
To the Sine of the said height, which is the height of the Style above the Substylar.

3. The Distance of the Substyl. from the Merid.

As the Radius
To the Sine of the Declination;
So the Cotang. of the Lat.
To the Tang. of the distance.

Look into the Table of Hours for Vertical Dials. If the Inclination of the Meridians be any of the Degrees and Minutes in the Table; whether whole Hour, half, or quarter: write the figure or mark thereof respectively in the middle of a half sheet of Paper, near the left hand side, in a narrow Column: and write against it *Mer. Substyl.* Then fill up the Column upward and downward with the Hours, Halves and Quarters, as they stand in the Table to six Hours each: with this Direction, If the Declination be East; place the Morning Hours: If West; the Evening Hours about the Subst. As in this Example, where the Incl. falls on the half hour past 10, the Decl. being East.

In another Column against the Quarters above and below *Mer. Substyl.* write 3.45: against the next 7.30, and so the rest as in this Table; These are the angles at the Pole.

		&c.
.		48.45
X		45.0
.		41.15
I		37.30
.		33.45
X		30.0
.		26.15
12		22.30
.		18.45
X		15.0
.		11.15
11		7.30
.		3.45
X		*Mer. Sub.*
.		3.45
10		7.30
.		11.15
X		15.0
.		18.45
9		22.30
.		26.15
X		30.0
.		33.45
8		37.30
.		41.15
X		45.0
.		&c.

If the Incl. falls not on a quarter: Set down *Mer. Subſt.* as before, in the middle: and continue the quarters between which it falls, upward and downward to ſix Hours, in ſuch a narrow Column.

Take the quarter in the Table of Hours next leſs than the Incl. out of the ſaid Incl. The Remain ſet againſt the ſaid quarter in another Column. Then take the Remain out of 3.45; This Remain Set againſt the quarter on the other ſide of *Mer. Subſt.* in the ſaid Column.

By a continual addition of 3°.45'. to theſe Remains, make up each row towards 90. not above: Theſe are the angles at the Pole. See the ſecond Example, where the Incl. is between three quarters paſt two; and Three: the Decl. Weſt.

In the continual Addition of 3.45, Shorten your work thus: Add only thrice above and thrice below: So you have the four firſt quarters on each ſide. Then to the firſt add 15 degrees (for the minutes alter not): then to the ſecond, and ſo to the reſt: which you may do by Inſpection. So have you two Hours on each ſide. Then beginning again, Add 30 degrees to the firſt, and continue your Addition of 30 in order, till it amounts to 90, not above. This is ſo eaſie, as you may account it as faſt as you can write.

	&c.
.	53.25
X	49.40
.	45.55
12	42.10
.	38.25
X	34.40
.	30.55
1	27.10
.	23.25
X	19.40
.	15.55
2	12.10
.	8.25
X	4.40
.	0.55
	Mer. Sub.
3	2.50
.	6.35
X	10.20
.	14.05
4	17.50
.	21.35
X	25.20
.	29.05
5	32.50
.	36.35
X	40.20
.	44.05
6	47.50
.	51.35
	&c.

Having

Having the angles at the Pole,
As the Radius
To the Sine of the height of the Style;
So the Tang. of the angle at the Pole
To the Tang. of the Arks of the Plain from the Subſtyl. to the Hour-points. To attain which, Take the courſe directed in the Horizontal Dial, by writing the Sine of the height, *&c.*

Set down the Tangents, every one againſt his own angle in another Column.

In a fourth ſet down the degrees and minutes anſwering theſe Tangents; Theſe are the Arks of the Plain.

In order to the finding the Chords belonging to theſe Arks; in a fifth Column ſet down the halves of theſe Arks. If the degrees be odd, ſet down the leſs half, and add 6 to the place of Tens in the minutes, and then halve them.

If the minutes of the whole be odd; note it in the half by annexing 5 at the right hand of the minutes.

In a ſixth, the Chords to the Semidiam. 5.

In a ſeventh, the ſaid Chords multiplied to any other Semidiam. according to the largeneſs of the Plain, and as you have uſe of them.

Ex. Of a plain declining Eaſt 12°. 45'. Lat. 52°. 20'.

	° '		
Sine of	52 . 20	*Ar. Compl.*	.10151
Tang. of	12 . 45		9.35464
Tang. of	15 . 57	*Incl. Mer.*	9.45615
Coſine of	52 . 20		9.78609
Coſine of	12 . 45		9.98916
Sine of	36 . 35	*Height of the Pole.*	9.77525
Sine of	12 . 45		9.34380
Co-Tang. of	52 . 20		9.88759
Tang. of	9 . 40	*Diſt. of Subſt.*	9.23139

Part

Part of the Table on each side the Subſtyl.

Hour.	An. Pol.	Tangents.	Ark. Pl.	H. Ark.	Co. for 5.	For other.
.	34.42	9.61561	22.26	11.13	1.9452	
1	30.57	9.55316	19.46	9.50	1.7078	
.	27.12	9.48615	17.02	8.31	1.4810	
X	23.27	9.41251	14.30	7.15	1.2620	
.	19.42	9.32919	12.03	6.015	1.0495	
12	15.57	9.23131	9.40	4.50	.8426	
.	12.12	9.11012	7.21	3.405	.6409	
X	8.27	8.94715	5.04	2.32	.4420	
.	4.42	8.69020	2.49	1.245	.2457	
11	0.57	7.99489	0.34	0.17	.0494	
Mer.	Subſtyl.					
.	2.48	8.46461	1.40	0.50	.1454	
X	6.33	8.83526	3.56	1.58	.3432	
.	10.18	9.03468	6.11	3.055	.5393	
10	14.03	9.17363	8.29	4.145	.7395	
.	17.48	9.28184	10.50	5.25	.9440	
X	21.33	9.37176	13.15	6.375	1.1536	
.	25.18	9.44983	15.44	7.52	1.3687	
9	29.03	9.51989	18.19	9.095	1.5916	
.	32.48	9.58444	21.01	10.305	1.8237	
X	36.33	9.64525	23.50	11.55	2.0649	

To Draw this Dial.

Placing it as it muſt be fixt, Draw a Vertical or Plumb-line in or near the middle: (if the Decl. were great; leave moſt ſpace on the Subſtyl. ſide) for the Meridian.

In this Line near the top chooſe a point for the Centre: And draw an Arch out of it, at as large a Semidiam. as the Plain will bear.

In this Arch ſet off the Subſtyl. from the Meridian, on the left hand, the Decl. being Eaſt (but if Weſt on the right): and draw it at full length through the Centre and this point.

Suppose this semidiam. 35 inches. The Chord in the Table against 12 (which is always the same with the distance of the Substyl. from the Merid.) is .8426 which multiplied by 7; (for so many times 5) The Product 5,8982 taken off the Scale (the last figure neglected) and prick'd down in the said Arch on the left hand of the Merid. giveth the point, through which and the Centre, the Substyl. must be drawn.

From this point set off the Chords, multiplied respectively, in the said Arch on either side. If the Chord exceed not 11 inches; it is on the Scale. But for the greater: open the Compasses to ten inches, and set as many of the said distances in the Meridian Line from the Centre, as it will bear, and note or account them 10, 20, 30, *&c.* So when any Chord is above 10, 20, 30, *&c.*; Take the excess off the Scale, and set it down in this Line from the point which it exceeds: and with a Pair of large or Beam-Compasses, Take the whole Line from the Center to this point. When the Chords go off the Plain; take a Semidiam. ten inches less.

Note, It is most convenient to set off the Substyl. from the Merid. at as large a Semidiam. as the Meridian Line will bear, by the first Direction in the first Chapter. But the hour points, at as large a Semidiam. of fives, as the said Line will bear, at first; and then less.

There ought to be no Hour-lines above the Horizont. Line that crosseth the Merid. at right Angles in the Center, in the South faces of these Plains: Although some points on the Substyl. side reach beyond it: But there being always a border at the top, and the Semidiam. small; you may perhaps set off a point or two above it; and drawing a Line from them beyond the Center, have their opposite points. But take a general Rule.

Take the half Arks of the uppermost and lowest quarters in your Column, each out of 45: The Sum of the Remains, add to the last half Ark on that side that wants

wants: Seek the Chord, multiply it, (if there be cauſe) and ſet it off from the Subſt. as before. If more be wanting, Take the difference of the laſt, and laſt ſave one, on the Subſtyl. ſide: Add it to the laſt Sum, and find the Chord, *&c.* And ſo proceed by taking the difference between the two next, adding it to the laſt, and finding the Chord, till all be ſupplied.

Having put on the points, you may deſcribe the border. Draw alſo two Lines parallel to the border; the inmoſt for the half hours, the other for the quarters, at convenient diſtances.

Then you may deſcribe a large Semi-circle out of the Centre for the whole Hour-lines. If the Declination be ſo great, as it cauſed you to ſet the Merid. near one ſide: Let it be an Arch greater than a Quadrant, or as far as about the middle between the Merid. and the border: and Draw a Line from the end thereof parallel to the Merid. up to the above-mentioned Horizont. line. Alſo croſs the Subſtyl. in the Center at right Angles with a ſhort Line.

Peirce the Centre perpendicular to the Plain with a Tapering Bit, till the Diam. of the hole be equal to the breadth of your Hour-line. Fill the hole with a round Peg, that may be about a quarter of an inch above the Plain: and thereon hang a fine Thread or Lute-ſtring by a nooſe ſo large, as it may turn round on the Peg. Stretch this ſtring juſt over the Hour-points, and with a pair of dividing Compaſſes opened to the breadth of the Hour-line, make two pricks near the border, intercepting the Thread juſt in the middle, and ſquare to the ſaid Thread.

Then laying a Rule to the Peg and the point anſwering; Draw the Line from the Semi-circle to the border for the whole Hours: but for the halves and quarters only from their reſpective Lines, and ſo go round. Then turn the Rule the other way, and applying it to the anſwering point, draw the other ſide of the Line in the ſame manner: Then fill it with ſome colour.

CAP. XII.

To find what Hours the Sun ſhineth on the North face of any upright Plain.

1. IF the face be direct North; ° ′

As the Tang. of *Tang.* 52.20 *Ar.Com.* 9.88759
the Lat. *Tang.* 23.30 9.63830

To the Tang. of the *Coſ.* 70.23 9.52589
Suns greateſt Declination;
So the Radius,

To the Coſine of the hour from the Merid. in which the Sun is due East or West.

In the Lat. of 52°. 20′. the time is 18′. after 7 in the Morning, and as many before 5 in the Evening. The Morning hours before, and the Evening hours after muſt be on the Plain.

If the Plain declines:

As the Cotang. of the Suns greateſt Declination
To the Cotang. of the Lat.;
So the Coſine of *Cotang.* 23.30 *Ar.Compl.* 9.63830
the Inclination of the Me- *Cotang.* 52.20 9.88759
ridians, *Coſine* 15.57 9.98295

To the Coſine of an *Coſine* 71.10 9.50884
Angle, Which added to that of the Inclination; The Sum turned into time is the hour and min. from Noon, in which the Sun leaves the Plain before Noon or comes on it after Noon (as the Plain reſpects the East or West) for the fewer hours: The difference is the time, as above, for the more hours. The Morning hours before, and the Evening hours after, muſt be on the Plain.

In the Example of the Plain beforementioned, The Decl. of the South face being toward the East; The North face is toward the West: Therefore the more hours are after Noon. The Sum is 87°.07′. The Sun in the longeſt day leaves the Plain 12′. after 6 in the

the Morning: The difference is 55°. 13′: Therefore he comes on it again 19′. before 4 after Noon. Wherefore the Hour-line of 6 and all before must be on one side: and a quarter before 4, and all after on the other.

3. If the Declination of the Plain be greater than the Amplitude in the greateſt Declination: The Sun ſhines on the Plain only before Noon, or only after Noon reſpectively. The Amplitude is the diſtance, in Degrees and Minutes of the Horizon, of the Sun's Riſing or Setting from the Eaſt or Weſt points: and is thus found,

		° ′		
As the Coſine of	*Coſine of*	52.20	*Ar. Compl.*	.21391
the Lat.	*Sine of*	23.30		9.60070
To the Radius;	*Sine of*	40.44	*Ampl.*	9.81461

So the Sine of the Sun's Decl.

To the Sine of the Ampl. So in the Lat. of 52°. 20′. and greateſt Decl. The Ampl. is 40°. 44′.

In theſe North faces the Style points upward. In a direct North Plain, Draw firſt an occult or obſcure Vertical Line through the middle of the Plain, for the Merid. and Subſtyl. Croſs it at right Angles, lower than the middle, with the Hour-line of 6. The interſection is the Centre. The Hour-lines are drawn as in the South face. The hours, that fall below 6, muſt be drawn from their oppoſite Lines, continued beyond the Centre, as in the Horizont. Dial.

The Morning hours are on the right hand of the Meridian, when the Dial is placed as fixt: The Evening on the left.

In the North-eaſt faces, the After-noon hours in the Table of hours muſt be ſet above and beneath *Mer. Subſt.* and ſo continued upward and downward, and the Subſtyl. on the right hand of the Meridian, when the Dial is placed, as above. In the North-weſt faces, the contrary, in both reſpects.

In the greater Decliners more ſpace muſt be left on the Subſtyl. ſide, and care muſt be taken to leave ſufficient ſpace for the hours that fall below the Centre.

When the Declination of the Plain exceeds the greatest Ampl.; The inside of the border may be the Meridian.

CAP. XIII.

Directions for great Decliners.

IN both faces of these upright Plains, the greater the Decl. is; the nearer the Hour-lines fall together.

Where they fall so near together, as you can scarce distinguish them; It is best to leave out the Centre.

Wherefore Draw the Dial at large upon Paper or Pastbord: If it be for a small Dial, (as in a Pain of Glass) Set off also the Style, according to its due height, on one side of the Substyl. So you may cut out as much thereof in a Square or Oblong, as will fit your design: And prick it down upon your Plain, and set the Style up at the heights answering the part cut off, without more trouble, than to draw an occult Line parallel to the Merid. in any place convenient, (before you cut it out,) for the due placing thereof.

But for a large Plain, It is best to Draw the Dial by two Tangent Lines, as followeth.

In your large draught above-mentioned you may omit most of the inward hours, and the trouble belonging to them, more than the Tangents of the Arks of the Plain.

Describe a small Square, the side parallel to the Merid. in a convenient place in your Draught: which may contain all or most of the Hour-lines and the Substyl.

Let the large Draught be A B D E. (*Fig.* IV.) The small Square G H D F. Within this small Square, Draw two parallel Lines Perpendicular to the Substyl. so as they cross all the Hour-lines, and yet be distant one from the other, as far as the Square will permit, *viz.* O P and Q R.

Measure

Meaſure the ſide of the ſmall Square, and the length of the Subſtyl. from the Centre to the points of Interſection with both theſe Lines. Theſe lengths are Semidiameters, and the croſs Lines Tangents to them.

Meaſure alſo the neareſt diſtance of the point of Interſection of the Semidiam. and Tang. furtheſt from the Centre, from each ſide of the Square next to it, as N I and L I.

Example.

Lat. 52°.20′. Decl. Weſt 82°.30′. The ſide of the ſmall Sq. 8 in. .4 The Semi-diameters C I and C M 17 in. .2 and 12 in. .16 Diſt. of I from F D, *viz.* L I 3 in. .46, the Diſt. thereof from H D, *viz.* N I 2 in. The Side of the Plain, whereon the Dial is to be drawn, within the border, ſuppoſed a Square 32 Inches. As the ſide of the little Square, to the ſide of your Plain; So the length C I to the larger Semi-diam. of your Plain. And, So the length C M to the leſs Semidiam. of your Plain. And, So the Diſtances L I and N I to their anſwering reſpective Diſtances in your Plain.

To find which the neareſt way; Take the difference of the Logs. of 8.4 and 32. *viz.* .58087 and add it to the Logs. of the third Numbers; the Sum ſhall give the length of the Lines belonging to your Plain, according to the *6th* Direction, *Cap. 2d.* The Semi-diam. C I will be 65.53. Semidiam. C M 46.32. The diſtance L I 13.18. And the diſtance N I 7.62. Alſo the difference of the Semidiameters, *viz.* The Line M I is 19.21 inch.

Coming now to your Plain: Fix the Point I according to his own Diſtances; wherein there is no need of exactneſs.

Through

Through it Draw an occult Vertical answering to KL. Out of I as a Centre, and as large a Semidiam. as the Plain will bear, Describe an occult Arch of a Circle from the Vertical on both sides. In it inscribe the distance of the Substyl. from the Meridian; and draw the Substyl. at full length through I and this point. Set off the Compl. of the distance on the other side of the Vertical, to make up a right Angle. Draw a Line at full length through this point and the Centre I: It shall be the greater of the two Tangents.

From I set off the difference of the Semi-diameters in the Substyl. toward the Centre of the Dial to M. Through this point draw the less Tang. parallel to the other.

As the Tang. of 45
To the length of each Semidiam.;
So the Tang. of the Ark of the Plain
To his respective distance of the Hour-point from the Substyl. And,
So the Tang. of the height of the Style
To his respective height above the Substyl.

These you may obtain with much ease and speed by holding the written Log. of each Semidiam. To the Tangents of the Arks of the Plain before found, and adding them, &c. according to the first Direction, Cap. 2. Having gathered these Distances into two Columns against their respective Tangents; set them off from the Substyl. in their proper Tang. Lines, and joyn the points with Lines continuing them beyond the points to the borders.

Then set up the Style over the Substyl. at the two heights assigned: or rather choose another point in the Substyl. nearer to the Centre, and find the height answering, by the length of the Semidiam. to it: and set it up accordingly.

The Directions of Mr. *Gunter*, concerning these great Decliners being very short, I have made them as plain as I can; and by the help of the Diagram, they are

are freed from the difficulty, which without it would have attended them.

CAP. XIV.

Directions in putting up the Style in Dials that have their Centres on the Plain.

THis depending on the Solution of a right-line Triangle; It will not be amiss to premise the usual Canons, whereby it is resolved. Noting first, That

1. In every right-line Triangle, the three Angles are equal to two right ones or 180 degrees. Therefore if one Angle be known, the Sum of the other two is known, and two being known, all are known.

2. In a right-angled Triangle, the right Angle being 90°; The other two are Complements, each of the other. Therefore if one be known, the other is also known.

3. The greater side is always opposite to the greater Angle, and on the contrary.

Prop. 1.

In a right-angled Triangle: If you make either side next the right Angle the Radius; The other is the Tang. of his opposite Angle. Therefore,

As the Tang. of 45°.
To the known side;
So the Tang. of the Angle opposite to the inquired side
To the inquired side.

Prop. 2.

In a right-angled Triangle: If you make the side opposite to the right Angle the Radius; The other sides are the Sines of their opposite Angles. Therefore,

As the Radius
To his opposite side;
So the Sine of either of the other Angles
To his opposite side.

Prop. 3.

Prop. 3.

In any Triangle: The ſides are proportional to the Sines of their oppoſite Angles. Therefore, the Angles and one ſide known:

As the Sine of any Angle given
To the oppoſite ſide;
So the Sine of either of the other Angles
To his oppoſite ſide.

So, having two ſides and an Angle oppoſite to either of them; The other Angles may be found, and the third ſide.

Prop. 4.

In any Triangle: Having two ſides, and the Angle comprehended by them: To find the other two Angles, and the third ſide.

As the Sum of the ſides
To their difference;
So the Tang. of half the Sum of the unknown Angles
To the Tang. of half their difference.

The Sum of the half Sum and half difference is the greater Angle: and their difference is the leſs. Having all the Angles; the third ſide may be found by the *Prop.* next before.

Prop. 5.

Having the three ſides; to find the Angles.

As the Baſe, the greater ſide,
To the Sum of the other ſides;
So the difference of the other ſides
To a fourth Number: which being taken out of the Baſe; the Perpendicular will fall on the middle of the Remainer. So you have two right-angled Triangles: in each two ſides known, and the right Angle oppoſite to one of them: from whence the other Angles and the third ſide may be found by the ſecond part of *Prop.* 3.

A far better way, after the manner of finding the Hour and Azimuth before delivered.

From half the Sum of the three ſides Deduct each ſide ſeverally,

To the Ar. Compl. of the Logs. of the half Sum and of the difference of the ſide oppoſite to any inquired Angle, Add the Logs. of the other two differences; Half the Sum is the Log. Tang. of half the inquired Angle: Then you may repeat the latter part of the work for one of the other Angles: or find them both by *Prop.* 4.

To put up the Style.

1. Add 90°, to the height thereof: Protract that Angle, and let one end of the Style be turned, as near as you can, to it. This turned part muſt not be full ſo long as the Dial is thick. Let it be ſomewhat tapering, with a Skrew at the end: and a Nut fitted to it, to be let in to the back of the Dial. Let the other end be rounded to a blunt point.

2. For the due length of the Style, as relating to the Hour: Take the length of the longeſt Hour-line on the Subſtyl. ſide of the Plain, from the Centre to the inner border: Whether it be whole Hour, half or quarter to the tenth of an inch: (which is ſufficient in this caſe) and note the Angle at the Pole belonging to it.

As the Radius
To the Coſine of the Angle at the Pole;
So the Cotang. of the height of the Style
To the Tang. of a firſt Angle.

The ſhadow of the Style being ſhorteſt in the greateſt Winter Declination of the Sun, on the South faces of theſe upright Plains: but in his greateſt Summer Declination, in the North faces;
Add 23°. 30′ to this Angle; The Sum is a ſecond Angle.

As

As the Cosine of 23°. 30',
To the Sine of the second Angle;
So the length of the Hour-line
To the length of the Style.

Note, If the Sun be beneath the Horizon at the hour belonging to the longest Hour-line; Find the Declination of the Sun answering the Ascensional difference of the said hour, by a converse of the Canon, *Cap.* 7. *viz.* As the Radius, To the Sine of the Ascensional difference;

So the Cotang. of the Lat. To the Tang. of the Declin. This Declination use in every respect, as you are directed to use the greatest; and you shall have a shorter, yet sufficient length of the Style.

3. Assign a point in the Substyl. at a convenient distance from the border, wherein to fix a Supporter. Then by *Prop.* 1.

As the Tang. of 45°.
To the length of the Substyl. from the Center to this point;
So the Tang. of the height of the Style,
To the length of the Supporter. To which must be allowed more for the greater part of the Eye, or hole, in which the style must rest: (which may be somewhat Oval) Also must be allowed at the other end near as much as the thickness of the Plank, for fixing it. The part to be driven into the Dial let be square, strong, and a little tapering, but not to a point: with a shoulder above it, for the driving it: Let it be made of good Iron, somewhat slender toward the Eye; that it may be bent or wrested any way for the due adjusting the style.

4. Draw or raze a short Line in the middle of the style on each side, which may point strait out at the turned end.

5. Having pierced a hole for the supporter; Drive it near to its depth. Put the style through it, and sink the turned end into his place at the Centre, till the razed

Lines

Lines before-mentioned fit exactly to the ſhort Line, directed to be drawn through the Centre Perpendicular to the Subſtyl. *Cap.* 11.

6. But to adjuſt it to the true height and place; Take the juſt length of it from the Centre. Then by *Prop.* 2.

As the Radius
To the length of the Style;
So the Coſine of the height
To the diſtance of the point in the Subſtyl. from the Centre, perpendicular under the end of the Style. And,
So the Sine of the height
To the diſtance of the end of the Style from the ſaid point.

7. In the largeſt Arch of the Plain, ſet off at a convenient equal diſtance two points, from the point of interſection with the Subſtyl.

8. If the Style be ſo placed, That the end thereof, or (where the Style is long) a point marked in the middle of the upper ſide thereof, (near Perpendicular to the ſaid point of interſection) be ſet at an equal diſtance from theſe two points: and the end of the Style be kept at his due diſtance from the point in the Subſtyl. right under it (either by driving or bending the Supporter, or both as you ſee cauſe) It ſhall be truly placed. Then skrew on the Nut, but not too hard.

9. In ſome Dials (North-faces eſpecially) the Style fitted to the due length, may reach beyond the Plain. If for the ſetting the Style to the juſt height, you would find the diſtance of the end of it from a point taken near the end of the Subſtylar. The length of the Style and the diſtance of the ſaid point from the Centre, are two ſides of a Triangle, comprehending a known Angle, *viz.* the height of the Style. So the ſum of the other two Angles being known; By *Prop.* 4. you may find both theſe Angles: And by *Prop.* 3. the third ſide, which is the diſtance ſought. But it is

placed best over the Substyl. by marking a point in the top of the Style, and proceeding according to the former Direction.

CAP. XV.

To find the Altitude of the Sun at every Hour in any Day in the Year.

1. IF the Sun be in the Æquator,
As the Radius
To the Cosine of the Latitude;
So the Cosine of the Hour from the Meridian
To the Sine of the Altitude.

2. If the Sun hath Declination; the Meridian Altitude will be found by the Declination.

If the Hour be six:
As the Radius
To the Sine of the Latitude,
So the Sine of the Declination
To the Sine of the Altitude.

3. If the Hour be neither twelve nor six:

As the Cosine of the Hour from the Meridian
To the Radius;
So the Tangent of the Lat.
To the Tangent of a fourth Ark.

Then, If the Lat. and Declination be both alike, as with us in the North Lat. North Declination, and the Hour be between Noon and Six; Take the Declination out of the fourth Ark; The Remainer shall be a fifth Ark.

But if either the Latitude and Declination be unlike, or the Hour fall between Six and Midnight; Add the Declination to the fourth Ark; the Sum shall be the fifth Ark.

Then,

Then, As the Sine of the fourth Ark
To the Sine of the Lat.;
So the Cosine of the fifth Ark
To the Sine of the Altitude.

So for any one Latitude, you may gather your fourth Arks into a Table; each against his own Hour: and against them in another Column the Differences between their respective Sines and the Sine of the Lat. So are they ready for Use. For having found the fifth Ark; you are only to subtract the difference out of the Cosine thereof; The Remainer is the Sine of the Altitude required.

Suns Declination.

Days	Jan.		Feb.		Mar.		Apr.		May		June	
	South		South		South		North		North		North	
1	21	41	13	42	3	20	8	40	18	7	23	11
2	21	31	13	22	2	56	9	2	18	22	23	15
3	21	21	13	2	2	32	9	23	18	37	23	18
4	21	10	12	41	2	9	9	45	18	51	23	21
5	20	58	12	21	1	45	10	6	19	6	23	24
6	20	47	11	59	1	21	10	27	19	19	23	26
7	20	34	11	38	0	59	10	48	19	33	23	27
8	20	22	11	17	0	34	11	9	19	46	23	29
9	20	9	10	56	0	10	11	30	19	59	23	30
10	19	56	10	34	No.	13	11	50	20	11	23	30
11	19	42	10	12	0	37	12	11	20	23	23	30
12	19	28	9	50	1	01	12	31	20	35	23	30
13	19	14	9	28	1	24	12	50	20	46	23	29
14	18	59	9	6	1	48	13	10	20	57	23	27
15	18	44	8	43	2	11	13	30	21	8	23	26
16	18	29	8	21	2	35	13	49	21	18	23	24
17	18	13	7	58	2	38	14	8	21	28	23	21
18	17	57	7	36	3	22	14	27	21	38	23	18
19	17	41	7	15	3	45	14	45	21	47	23	15
20	17	24	6	50	4	8	15	3	21	56	23	11
21	17	7	6	27	4	31	15	21	22	4	23	7
22	16	50	6	4	4	54	15	39	22	12	23	3
23	16	32	5	40	5	17	15	57	22	20	22	58
24	16	14	5	17	5	40	16	14	22	27	22	53
25	15	56	4	54	6	03	16	31	22	34	22	47
26	15	38	4	30	6	26	16	48	22	41	22	41
27	15	20	4	7	6	49	17	4	22	47	22	34
28	15	0	3	43	7	11	17	21	22	58	22	27
29	14	41			7	33	17	37	22	58	22	20
30	14	22			7	56	17	52	23	3	22	12
31	14	2			8	18			23	7		

An. 1681		1685		1689	
July	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
North	North	North	South	South	South
22 4	15 6	4 17	7 21	17 43	23 8
21 56	14 48	3 54	7 44	17 59	23 13
21 47	14 30	3 31	8 6	18 15	23 16
21 38	14 11	3 8	8 29	18 31	23 20
21 28	13 52	2 45	8 51	18 46	23 23
21 18	13 33	2 21	9 13	19 1	23 25
21 8	13 14	1 58	9 35	19 16	23 27
20 58	12 54	1 35	9 56	19 30	23 28
20 47	12 35	1 11	10 19	19 44	23 29
20 35	12 15	0 48	10 40	19 57	23 30
20 24	11 55	0 24	11 2	20 10	23 30
20 12	11 35	0 1	11 23	20 23	23 30
19 59	11 14	So. 22	11 44	20 36	23 29
19 47	10 53	0 46	12 5	20 48	23 27
19 34	10 33	1 9	12 26	20 50	23 25
19 20	10 12	1 33	12 46	21 11	23 23
19 7	9 51	1 56	13 7	21 21	23 20
18 53	9 29	2 20	13 27	21 32	23 17
18 38	9 7	2 44	13 47	21 42	23 13
18 24	8 46	3 7	14 7	21 51	23 9
18 9	8 24	3 30	14 26	22 1	23 4
17 54	8 2	3 54	14 45	22 9	22 59
17 38	7 40	4 17	15 4	22 18	22 54
17 22	7 18	4 40	15 23	22 26	22 48
17 6	6 56	5 3	15 41	22 33	22 41
16 50	6 34	5 27	16 0	22 40	22 34
16 33	6 11	5 50	16 18	22 47	22 27
16 16	5 48	6 12	16 35	22 53	22 19
15 59	5 26	6 36	16 53	22 58	22 11
15 42	5 3	6 58	17 10	23 3	22 2
15 24	4 40		17 27		21 53

Suns Declination.

Days.	Jan.	Feb.	Mar.	Apr.	May	June
	South	South	South	North	North	North
1	21 43	13 47	3 26	8 34	18 4	23 11
2	21 33	13 27	3 02	8 56	18 19	23 14
3	21 23	13 7	2 38	9 58	18 34	23 18
4	21 12	12 46	2 15	9 40	18 48	23 21
5	21 1	12 25	1 51	10 1	19 2	23 23
6	20 49	12 5	1 27	10 22	19 16	23 25
7	20 37	11 43	1 03	10 43	19 29	23 27
8	20 25	11 22	0 40	11 4	19 43	23 28
9	20 12	11 1	0 16	11 25	19 55	23 29
10	19 59	10 39	Nor. 4	11 45	20 8	23 30
11	19 46	10 17	0 31	12 6	20 20	23 30
12	19 32	9 55	0 55	12 26	20 32	23 30
13	19 18	9 33	1 19	12 46	20 44	23 29
14	19 3	9 11	1 42	13 5	20 55	23 28
15	18 48	8 49	2 05	13 25	21 5	23 26
16	18 33	8 26	2 29	13 44	21 16	23 24
17	18 17	8 4	2 53	14 3	21 26	23 22
18	18 1	7 41	3 16	14 22	21 36	23 19
19	17 45	7 18	3 39	14 41	21 45	23 16
20	17 28	6 55	4 03	14 59	21 54	23 12
21	17 11	6 32	4 26	15 17	22 2	23 8
22	16 54	6 9	4 49	15 35	22 10	23 4
23	16 37	5 46	5 12	15 53	22 18	22 59
24	16 19	5 23	5 35	16 10	22 26	22 54
25	16 1	4 59	5 58	16 27	22 33	22 48
26	15 42	4 36	6 21	16 44	22 39	22 42
27	15 24	4 12	6 43	17 0	22 45	22 36
28	15 5	3 49	7 05	17 17	22 51	22 29
29	14 46		7 28	17 33	22 57	22 22
30	14 27		7 50	17 48	23 2	22 14
31	14 7		8 12		23 6	

An. 1682				1686				1690	
July		Aug.		Sept.		Oct.		Nov.	Dec.
North		North		North		South		South	South
22	6	15	11	4	23	7	15	17 39	23 7
21	58	14	53	4	0	7	38	17 55	23 11
21	49	14	34	3	37	8	1	18 12	23 15
21	40	14	16	3	14	8	23	18 27	23 19
21	31	13	57	2	50	8	46	18 42	23 22
21	21	13	38	2	27	9	8	18 58	23 24
21	11	13	19	2	04	9	30	19 12	23 26
21	0	12	59	1	40	9	52	19 26	23 28
20	49	12	39	1	17	10	13	19 40	23 29
20	38	12	20	0	53	10	35	19 54	23 30
20	27	12	0	0	30	10	57	20 7	23 30
20	14	11	40	0	7	11	18	20 20	23 30
20	2	11	19	So.	17	11	39	20 33	23 29
19	50	10	58	0	40	12	0	20 45	23 28
19	37	10	38	1	04	12	21	20 57	23 26
19	23	10	17	1	27	12	41	21 8	23 24
19	10	9	56	1	51	13	2	21 19	23 21
18	56	9	34	2	14	13	22	21 29	23 18
18	42	9	13	2	38	13	42	21 39	23 14
18	27	8	51	3	01	14	2	21 49	23 10
18	12	8	26	3	25	14	21	21 58	23 6
17	57	8	8	3	48	14	41	22 7	23 1
17	42	7	46	4	11	15	0	22 16	22 55
17	26	7	24	4	34	15	18	22 24	22 49
17	10	7	1	4	58	15	37	22 31	22 43
16	54	6	39	5	21	15	55	22 38	22 36
16	37	6	17	5	44	16	13	22 45	22 29
16	21	5	54	6	7	16	31	22 51	22 21
16	3	5	31	6	30	16	49	22 57	22 13
15	46	5	8	6	53	17	6	23 2	22 4
15	28	4	46			17	23		21 55

Suns Declination. 1683

Days.	Jan. South	Feb. South	Mar. South	Apr. North	May North	June North
1	21 46	13 52	3 31	8 29	18 0	23 10
2	21 36	13 32	3 8	8 51	18 15	23 13
3	21 26	13 12	2 44	9 13	18 30	23 17
4	21 15	12 51	2 20	9 34	18 44	23 20
5	21 4	12 31	1 57	9 56	18 59	23 23
6	20 52	12 10	1 33	10 17	19 13	23 25
7	20 40	11 49	1 9	10 38	19 26	23 27
8	20 28	11 28	0 45	10 59	19 40	23 28
9	20 15	11 6	0 22	11 20	19 52	23 29
10	20 2	10 44	Nor. 2	11 40	20 5	23 30
11	19 49	10 23	0 26	12 1	20 17	23 30
12	19 35	10 1	0 49	12 21	20 29	23 30
13	19 21	9 39	1 13	12 41	20 41	23 29
14	19 7	9 17	1 36	13 0	20 52	23 28
15	18 52	8 54	2 0	13 20	21 3	23 27
16	18 36	8 32	2 23	13 40	21 13	23 25
17	18 21	8 9	2 47	13 59	21 24	23 22
18	18 5	7 46	3 10	14 18	21 33	23 20
19	17 49	7 24	3 34	14 36	21 43	23 17
20	17 32	7 1	3 57	14 55	21 52	23 13
21	17 15	6 38	4 20	15 13	22 0	23 9
22	16 58	6 15	4 43	15 31	22 8	23 5
23	16 41	5 52	5 6	15 48	22 16	23 0
24	16 23	5 28	5 29	16 6	22 24	22 55
25	16 5	5 5	5 52	16 23	22 31	22 50
26	15 47	4 42	6 15	16 40	22 38	22 44
27	15 28	4 18	6 37	16 56	22 44	22 37
28	15 10	3 55	7 0	17 13	22 50	22 31
29	14 50		7 23	17 29	22 55	22 24
30	14 31		7 45	17 44	23 0	22 16
31	14 12		8 7		23 5	

1687 1691

July.	Aug.	Sept.	Oct.	Nov.	Dec.
North	North	North	South	South	South
22 8	15 15	4 28	7 10	17 35	23 6
22 0	14 57	4 5	7 33	17 52	23 11
21 51	14 39	3 42	7 55	18 8	23 15
21 43	14 20	3 19	8 18	18 23	23 18
21 33	14 1	2 56	8 40	18 39	23 21
21 23	13 43	2 33	9 2	18 54	23 24
21 13	13 23	2 9	9 24	19 9	23 26
21 3	13 4	1 46	9 47	19 23	23 28
20 52	12 44	1 23	10 8	19 37	23 29
20 41	12 24	0 59	10 30	19 51	23 30
20 29	12 5	0 36	10 51	20 4	23 30
20 18	11 44	0 12	11 13	20 17	23 30
20 5	11 24	Sou. 11	11 34	20 30	23 29
19 53	11 3	0 35	11 55	20 42	23 28
19 40	10 43	0 58	12 16	20 54	23 26
19 27	10 22	1 27	12 36	21 5	23 24
19 13	10 01	1 45	12 57	21 16	23 22
19 0	9 40	2 9	13 17	21 27	23 19
18 45	9 18	2 32	13 37	21 37	23 15
18 31	8 56	2 55	13 57	21 47	23 11
18 16	8 35	3 19	14 17	21 56	23 7
18 1	8 13	3 42	14 36	22 5	23 2
17 46	7 51	4 6	14 55	22 14	22 57
17 30	7 29	4 29	15 14	22 22	22 51
17 14	7 7	4 52	15 32	22 29	22 44
16 58	6 44	5 15	15 51	22 37	22 38
16 42	6 22	5 38	16 9	22 43	22 31
16 25	5 59	6 2	16 27	22 50	22 23
16 8	5 37	6 24	16 44	22 56	22 15
15 50	5 14	6 47	17 2	23 1	22 6
15 33	4 51		17 19		21 58

Suns Declination. 1684

Days.	Jan. South	Feb. South	Mar. South	Apr. North	May North	June North
1	21 48	13 57	3 13	8 46	18 10	23 12
2	21 38	13 37	2 50	9 7	18 27	23 16
3	21 28	13 17	2 26	9 29	18 41	23 19
4	22 18	11 56	2 2	9 51	18 55	23 22
5	21 7	12 36	1 39	10 12	19 9	23 24
6	20 55	12 15	1 15	10 33	19 23	23 26
7	20 43	11 54	0 51	10 54	19 36	23 28
8	20 31	11 32	0 28	11 15	19 49	23 29
9	20 19	11 11	0 4	11 35	20 2	23 30
10	20 5	10 50	No. 20	11 56	20 14	23 30
11	19 52	10 28	0 43	12 16	20 27	23 30
12	19 38	10 6	1 7	12 36	20 38	23 29
13	19 24	9 44	1 30	12 56	20 49	23 28
14	19 10	9 22	1 54	13 15	21 0	23 27
15	18 55	9 0	2 18	13 35	21 11	23 25
16	18 40	8 37	2 41	13 54	21 21	23 23
17	18 24	8 15	3 5	14 13	21 31	23 20
18	18 9	7 52	3 28	14 32	21 40	23 17
19	17 53	7 29	3 51	14 50	21 49	23 14
20	17 36	7 7	4 14	15 8	21 58	23 10
21	17 20	6 44	4 38	15 26	22 7	23 6
22	17 2	6 21	5 1	15 44	22 14	23 1
23	16 45	5 57	5 24	16 2	22 22	22 56
24	16 27	5 34	5 47	16 19	22 29	22 51
25	16 10	5 11	6 9	16 36	22 36	22 45
26	15 51	4 47	6 32	16 52	22 43	22 39
27	15 33	4 24	6 55	17 9	22 49	22 32
28	15 14	4 1	7 17	17 25	22 54	22 25
29	14 55	3 37	7 39	17 41	22 59	22 18
30	14 36		8 2	17 56	23 4	22 10
31	14 16		8 24		23 9	

1688 1692

Fuly	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
North	North	North	South	South	South
22 2	15 1	4 11	7 27	17 48	23 9
21 54	14 43	3 48	7 50	18 4	23 14
21 45	14 21	3 25	8 12	18 20	23 17
21 35	14 6	3 2	8 35	18 35	23 21
21 26	13 47	2 38	8 57	18 50	23 23
21 16	13 28	2 15	9 18	19 5	23 26
21 5	13 9	1 52	9 41	19 20	23 27
20 55	12 49	1 28	10 3	19 34	23 29
20 44	12 29	1 5	10 25	19 47	23 30
20 32	12 10	0 41	10 46	19 01	23 30
20 21	11 49	0 18	11 8	20 14	23 30
20 8	11 29	Sou. 6	11 29	20 27	23 29
19 56	11 8	0 29	11 50	20 39	23 28
19 43	10 48	0 53	12 11	20 51	23 27
19 30	10 27	1 16	12 32	21 2	23 25
19 17	10 6	1 40	12 52	21 13	23 22
19 3	9 45	2 3	13 12	21 24	23 19
18 49	9 23	2 27	13 32	21 35	23 16
18 34	9 2	2 50	13 52	21 44	23 12
18 20	8 40	3 13	14 12	21 54	23 8
18 5	8 18	3 37	14 31	22 3	23 3
17 50	7 56	4 0	14 50	22 12	22 58
17 34	7 34	4 23	15 9	22 20	22 52
17 18	7 12	4 47	15 28	22 28	22 46
17 2	6 50	5 10	15 47	22 35	22 39
16 46	6 27	5 33	16 5	22 42	22 32
16 29	6 5	5 56	16 23	22 48	22 25
16 12	5 42	6 19	16 40	22 54	22 17
15 55	5 20	6 42	16 58	23 0	22 9
15 37	4 57	7 5	17 15	23 5	22 0
15 20	4 34		17 31		21 51

A TABLE of Seconds for rectifying the Table of the Suns Declination.

	Ja.	Fe.	Mar.	A.	M.	Jun.	Jul.	Au.	Sep.	Oct.	No.	De.
	Se.	Se.	Se.	Se.	Se.	Se.	Se.	Se.	Se.	Se.	Se.	Se.
1	17	36	43	40	28	8	15	33	42	41	30	9
2	18	37	43	39	28	7	15	34	43	42	29	8
3	19	37	43	40	27	6	16	35	43	42	29	7
4	20	38	44	40	27	5	17	35	43	42	28	6
5	20	37	44	39	26	4	18	34	43	41	28	5
6	21	37	43	39	25	4	19	35	43	41	28	4
7	21	38	43	38	25	3	19	35	44	41	27	3
8	22	39	43	38	24	2	19	35	43	40	26	2
9	23	38	44	38	23	2	20	36	44	40	25	1
10	24	38	45	37	23	1	21	36	43	40	24	1
11	25	39	44	37	22	0	21	37	43	40	24	0
12	25	40	44	37	22	1	22	38	43	39	23	0
13	26	41	43	36	21	1	22	38	43	39	22	1
14	26	40	44	36	20	2	23	38	44	38	21	2
15	27	41	44	35	20	3	23	38	43	38	21	3
16	28	42	43	35	19	4	24	39	44	37	20	4
17	28	41	42	35	19	4	25	39	43	38	20	5
18	29	41	43	35	18	5	26	39	43	37	19	6
19	30	41	43	34	17	6	26	39	43	37	18	7
20	31	42	42	34	17	7	27	40	43	36	17	8
21	31	42	43	33	16	8	27	40	43	36	16	9
22	32	42	43	33	15	8	28	41	44	35	16	10
23	32	43	43	32	14	9	29	40	43	35	15	11
24	32	43	42	32	14	10	29	41	42	34	14	12
25	33	44	42	31	13	11	30	41	43	34	13	12
26	33	44	41	31	12	12	30	41	42	33	13	13
27	34	43	41	30	11	13	30	41	42	34	12	14
28	34	43	41	29	10	13	31	42	42	33	11	15
29	35	43	41	29	9	14	31	41	43	32	11	16
30	35	—	41	29	9	14	32	42	42	32	10	16
31	36		41		8		33	42		31		17

The Uſe of the Table of Seconds.

We will ſuppoſe that the Tables of the Declin. were calculated for the four middle years, *viz.* 1685, 1686, 1687, 1688.

Subtract 1688 out of the year to which you would rectify the Declination.

The Difference divide by 4. If any Number remain; it ſhews in which of the three former years you muſt ſeek the Declination. If nothing remain; Seek it in the laſt.

By the Quotient (being the Number of Leap-years paſt ſince 1688) Multiply the Seconds found in this Table againſt the Day of the Month, in which you ſeek the Declination.

Divide the Product by 60. The Quotient add to the Declination in the Table, if the Declin. increaſeth, *viz.* in the Spring or Autumn Quarter: But deduct it, if the Declin. decreaſeth, *viz.* in the Summer or Winter Quarters. The Sum or Remainer is the true Decl. for that day at Noon.

Then for the Hours before or after Noon.

As 24

To the Difference of the Declin. in the Table in Minutes for one Day before or after;

So the Hour from Noon

To his proportional part, which muſt be added or deducted according as the Declin. increaſeth, or decreaſeth: alſo with reſpect to the time before or after Noon.

Examp. I would know the Declination of the Sun at 7 in the Morning on the firſt Day of *April* 1723: Taking 1688 out of 1723: The difference is 35. which divided by 4; the Quotient is 8: and there remain 3, which ſheweth that you muſt ſeek the Declination in the third Table.

The Seconds in the Table are 40, which multiplied by the Quotient; The Product is 320. This divided

by 60; The Quotient is 5: The Remainer may be lected in this case.

The Declination in the Table is 8°. 29′. increasing. To which if you add the said 5; The Sum 8°. 34′. is the Declination that Day at Noon.

The Difference for a Day before or after is 22. On the double Scale: Set 24 to 22; against 5 the hour from Noon is 4.6 which you may call 5, for we regard not parts, as is before said.

This must be deducted out of the Declin. at Noon; because the Declination increasing; it is not amounted to that at Noon by so many Minutes.

To

To Guage a Cask which is not full.

A Table for Guaging of Wine Casks which are not full.

G.	parts.	G.	parts.	G.	parts.	G.	parts.	G.	parts.
0	000	13	2630	26	4330	39	5913	52	7672
1	295		2703		4400		5976		7758
2	470	14	2775	27	4462	40	6040	53	7829
1	602		2847		4542		6094		7909
	720	15	2918	28	4585	41	6158	54	7990
2	830		2986		4646		6223		8072
3	935	16	3056	29	4706	42	6288	55	8154
	1038		3123		4766		6353		8236
4	1138	17	3189	30	4826	43	6418	56	8319
	1235		3255		4885		6483		8404
5	1329	18	3321	31	4943	44	6548	57	8491
	1420		3387		5000		6613		8580
6	1502	19	3452	32	5057	45	6679	58	8661
	1596		3517		5115		6745		8765
7	1681	20	3582	33	5174	46	6841	59	8862
	1764		3647		5234		6877		8962
8	1846	21	3712	34	5294	47	6944	60	9065
	1928		3777		5354		7012		9170
9	2010	22	3842	35	5415	48	7082	61	9280
	2091		3906		5476		7153		9398
10	2171	23	3960	36	5535	49	7225	62	9530
	2242		4024		5600		7297		9705
11	2328	24	4087	37	5662	50	7370	63	10000
	2405		4150		5724		7444		
12	2481	25	4213	38	5787	51	7519		
	2556		4270		5850		7595		

FInd the content of the whole Cask, and the depth of the Liquor therein, being the wet part of the Bung-Diam. the Axis of the Veſſel being Horizontal or Level. As the Diam. at the Bung in Inches, to the depth of the Liquor; ſo 10,000 the Radius of the Table, to the proportional part. Find in the Table the ſaid Parts or neareſt, and note the Gallons and parts anſwering. Then as 63, the Gallons in a Wine Hogſhead, to the Gallons noted; ſo the content of the whole Cask, to the content of the Liquor in the Cask.

Gunter's *Chain otherwiſe diſtinguiſhed.*

THE diſtinction of this Chain, as I have uſed it above thirty years, without finding the leaſt inconvenience or cauſe to alter it, I have here inſerted.

At ten links, and at thirty links from each end, let there be a braſs Curtain Ring, or (if you like it better) a round braſs Plate. At twenty links, and at forty links from each end, ſuch another Ring, with a red, yellow, or ſome other remarkable coloured Ragg, ſewed, or otherwiſe faſtned thereto. At twenty five links from each end, two ſuch Rings together. At fifty links, a large braſs Ring of about an inch and half Diam.

The convenience of this Diſtinction.

1. THE Surveyor of Land will ſometimes find his Chain at the end of the meaſured line, lying in Stubble, long Graſs, or Weeds; ſometimes foul with Mire or Dirt, through which it hath been led, or in which it lyeth: In ſuch caſe, the Raggs are eaſily diſcoverable.

2. They

2. They being but four, and accounted 20, 40, 60, 80, from each end; the link that determines the length of the line is ſpeedily found.

3. Every mark of diſtinction in the Chain, except one, repreſenting two Numbers; the Raggs and Rings are free for either. But that which is defined to one, and yet muſt as often ſignify another, may be the cauſe of loſs of time, or (which is worſe) of a miſtake.

Notwithſtanding, it is free to any to diſtinguiſh his Chain as he pleaſeth.

ERRATA.

PAg. 4. l. 14. r. 87: ibid. r. 22: p. 5. l. 7. for *Decimals* r. *Number*: p. 6. l. 22. r. 02: p. 13. *the Decimal of* 4 d. $\frac{3}{4}$ r. .0197916: p. 14. *Decimal of* 22 *l.* r..1964286: p. 31. l. 35. r. 1 $\frac{1}{4}$ *l*: p. 34. l. the laſt, r. *next above*: p. 36. l. 23. r. *the two following*: p. 40. l. 21. r. *Part II*: p. 45. at the bottom r. 1.55630. and 2.52800: p. 48. l. 27. r. 9. 97: p. 80. l. 34. r. *Hour-lines*: p. 88. l. 15. r. 2. *If the*: In the Tables of the Suns declination, *Anno* 1681 *Feb.* 19. r. 7. 13: and *May* 28. r. 22. 53: *Anno* 1682. *Aug.* 21. r. 8. 29: *Anno* 1684. *Nov.* 10, r. 20.01.

Adver-

Advertiſement.

WHereas the Tables of Logarithms, of Sines, Tangents, and Natural Numbers, had they been inſerted, would have ſwelled this Book, and thereby advanced the price beyond the deſign thereof; I recommend to the Reader *Gellibrands* Inſtitution Trigonometrical, wherein are Tables of the Natural Sines Tangents and Secants, and alſo the Log. Sines, and Tangents: Together with a Table of Log. as far as 10,000 in a very fair figure and very true. There is ſuch another in every reſpect by one *Vlacq* a *Dutchman*. One of theſe with Mr. *Wingate*'s *Tabulæ Logarithmicæ*, recommended in the Book, will be ſufficient for almoſt any Mathematical Practice. And he will reap by them the ſatisfaction which will abundantly anſwer the charge.

F I N I S.

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Books

Books lately Printed for *Tho. Bennet*, at the *Half-moon*, in *St. Paul's* Church-yard.

HOmeri Iliados Liber Primus. In quo ſingularum vocum ſignificationes, compoſitiones ac derivationes annotantur: Dialecti clare & diſtincte exponuntur: Synonyma multis locis adjiciuntur: Particularum varii ac elegantes uſus demonſtrantur, Phraſes & Sententiæ ex ipſo textu delinguntur: Græciſmi paſſim occurrentes explanantur: Fabulæ & Hiſtoriæ nominum propriorum enarrantur: omnia denique, quæ huc pertinere videbantur, ita continentur, ut is facile a quovis intelligatur, methoduſque vera Linguam Græcam tum docendi, tum diſcendi habeatur. Studio & Opera *Georg. Sylvani*, Pan. Med. *Editio Secunda.*

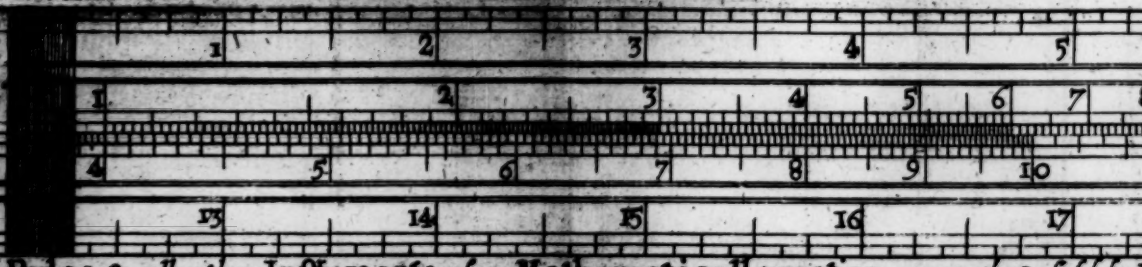
Doctor *Busby*'s Greek Grammer newly Reprinted, with conſiderable Corrections.

A Critical Hiſtory of the Text of the New Teſtament, where is firmly Eſtabliſh'd the Truths of thoſe Acts, in which the Foundation of Chriſtian Religion is laid; by Father *Simon* of the Oratory, compleating his Criticiſms on the whole Bible.

The Second Part of Mr. *Waller*'s Poems. Containing his Alteration of the Maids Tragedy, and whatever of his is yet unprinted: Together with ſome other Poems, Speeches, *&c.* that were printed ſeverally, and never put into the Firſt Collection of his Poems.

F I N I S.

Fig: I



These Rules & *all other* Instruments *for* Mathematicall practice *are made & sold by*

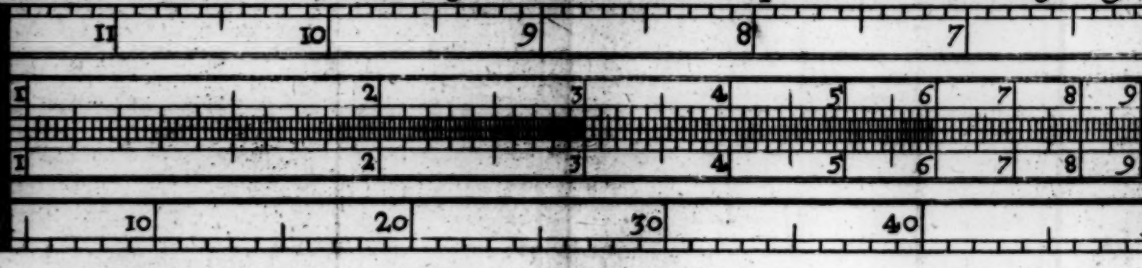


Fig. III.
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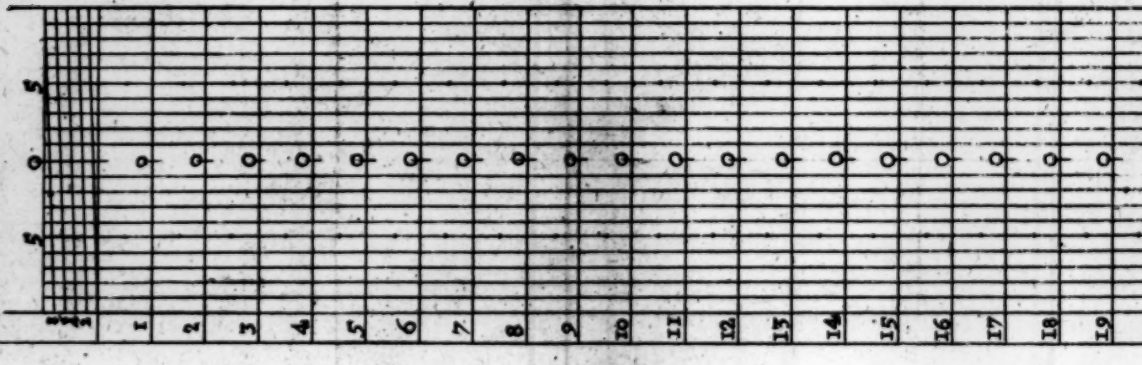
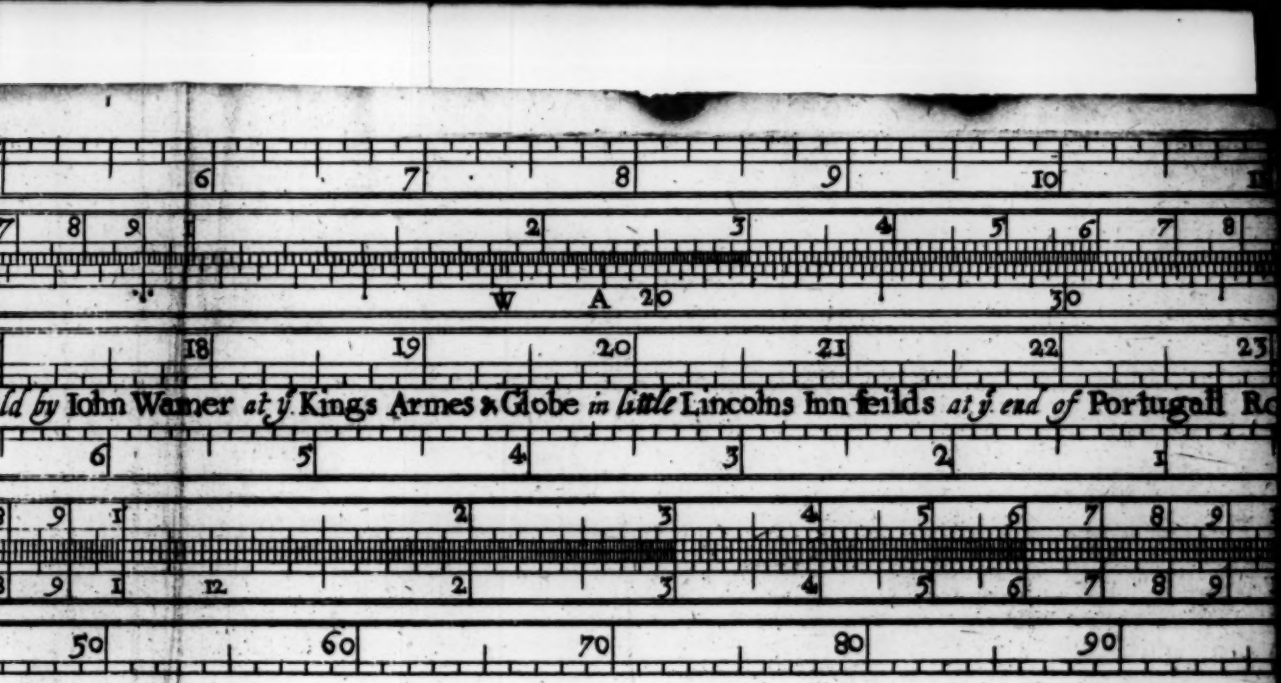
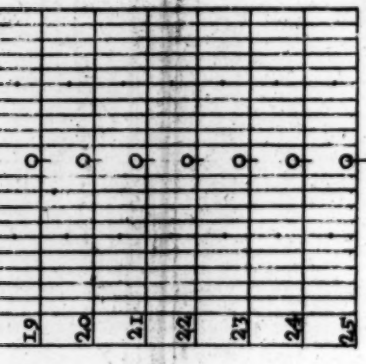




ld by Iohn Warner at y. Kings Armes & Globe in little Lincolns Inn feilds at y. end of Portugall Ro



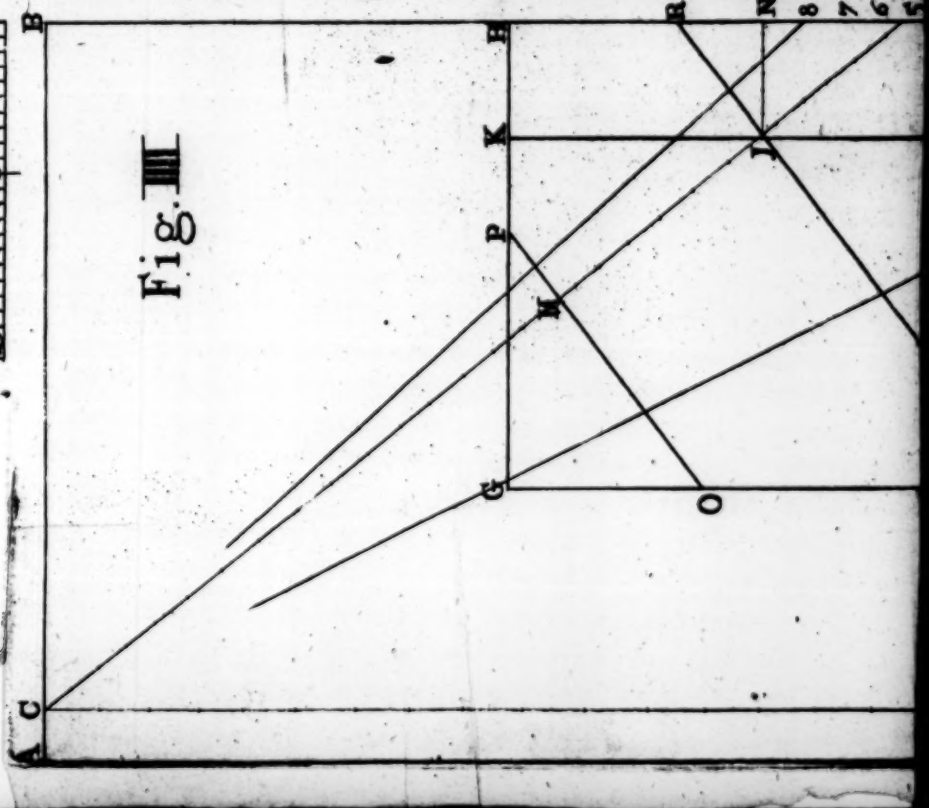
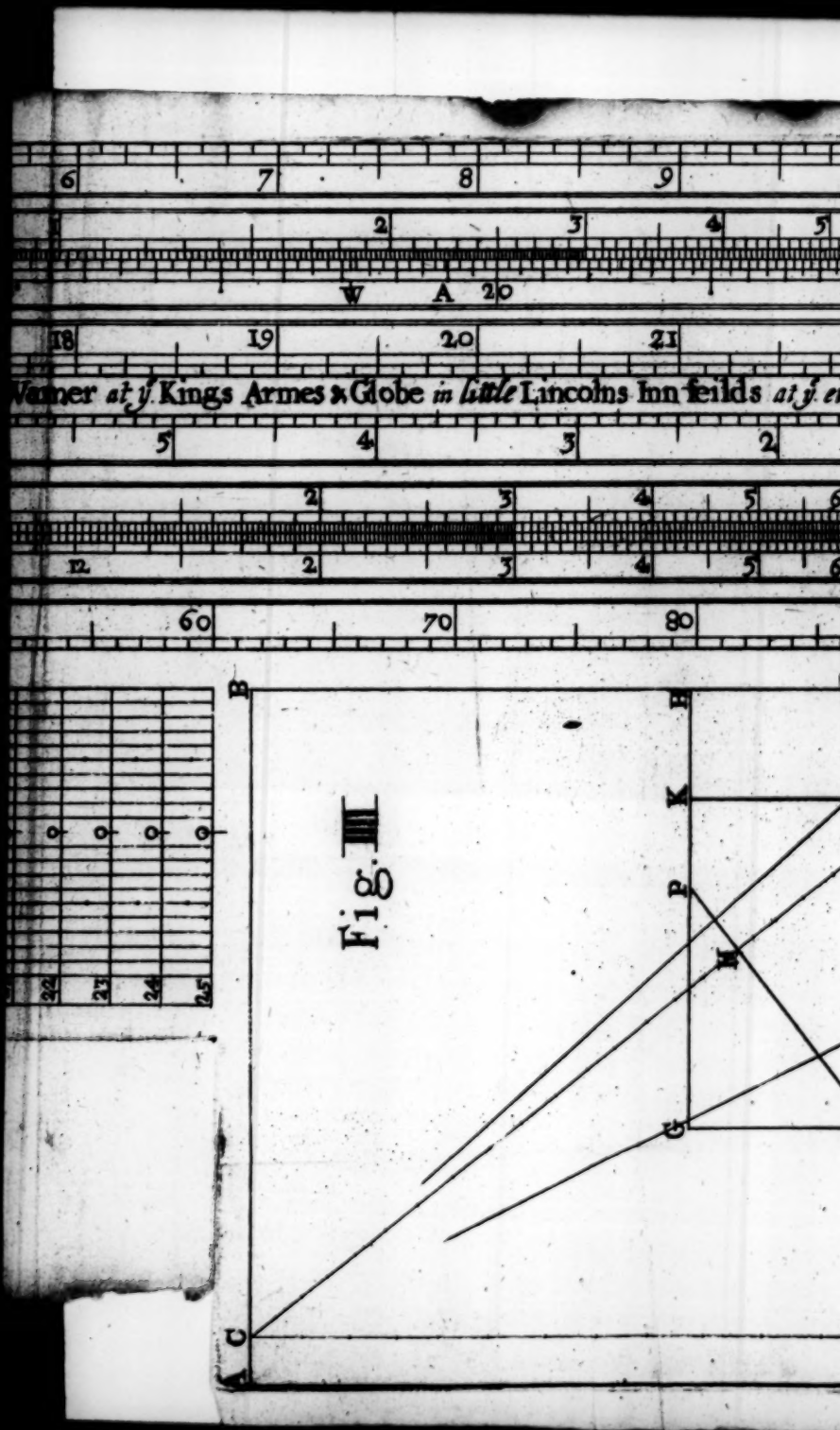


Fig. III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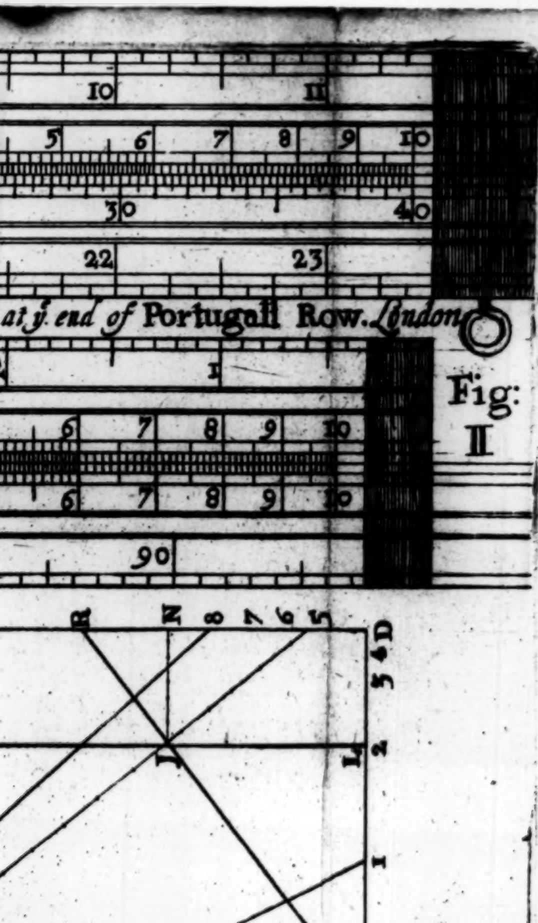
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Fig: II
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